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ORIGINAL ARTICLES.

I.—Some Lake Basins in Alberta and British Columbia.

By J. Parkinson, F.G.S.

(PLATE VI.)

FOR several years careful study has been given to numerous lake basins in England and elsewhere, with the result that many previously considered as rock basins have not survived the ordeal. Professor Bonney,[1] who has always opposed this hypothesis in the case of large lakes, has described four authentic examples from the Lepontine Alps, three of which I had the advantage of visiting with him; and some few weeks before, Mr. Brend[2] described others from Caernarvonshire.

It may therefore be of interest to call attention to two lakes in the Canadian Rocky Mountains and one from the Selkirk Range which may lay claim to the rather rare distinction of being true rock basins. We will take the former first. The country between the Columbia River on the west and the infold of Cretaceous rock, known as the Cascade trough, on the east in the neighbourhood of Banff, is one of the most delightful that a traveller can enjoy. The east-bound train on the Canadian Pacific Railway, after leaving the Columbia River at Golden, the northern end of the Columbia Kootanie Valley, follows the course of the Kicking Horse River until the watershed between the Pacific and Atlantic slopes is reached a little to the west of Laggan. With the exception of a long strip of country between the Ottertail Mountains and the Vermilion Range to the south of the Kicking Horse River, which is mapped as "igneous intrusive,"[3] the whole of the country comprised in the area specified above is sedimentary. The line of the railway passes over the Canadian Quartzite series to Silver City on the Bow River, some seventeen miles to the east of Laggan. To the east of this, again, lies the north-west Cretaceous fold.

[1] Geol. Mag., 1898, p. 15.
[2] Geol. Mag., 1897, p. 404.
[3] "Reconnaissance Map of a portion of the Rocky Mountains between 49° and 51° 30′": Canada Geol. Surv., 1885.

The geological structure of this district is described by Mr. R. G. McConnell,[1] and it will be sufficient to refer to the salient points. Mr. McConnell divides this region into two nearly equal parts, taking the western side of the Sawback Range as the line of division. To the east of this line the dip is consistently to the west, due to the fact that a thrust from that direction has produced a series of roughly parallel ridges, which have been "tilted and shoved over one another into the form of a westerly dipping compound monocline." Rundle and Cascade Mountains, near Banff, are examples of this type. On the western side as far as the Columbia River no reversed faults are found, and "ordinary and overturned folds play the most important rôle." The lakes which form the subject of the present note lie in the latter division some two miles to the west of Laggan (5,008 feet). They are three in number. Lake Louise, the largest, a mile and a quarter long, lies at a height of 5,645 feet above sea-level, and Lakes Mirror and Agnes, overlooking their larger confrère, at heights of 6,500 feet and 6,820 feet respectively. They have been described from the point of view of the explorer and climber by Mr. Walter D. Wilcox, in his interesting and admirably illustrated book "The Canadian Rockies," from which the figures in Pl. VI are taken. At the end of this work an excellent map of this region is given, and he has also recently published a contour map and detailed study of Lake Louise.[2] Mr. Wilcox refers to Lake Agnes as being certainly a rock basin, and remarks elsewhere[2] that only two rock-basin lakes were observed by him, "one of which was a typical cirque lake," no doubt Lake Agnes. This little lake is about a third of a mile long and about 150 yards across, and is surrounded on three sides by mountains. The upper end is a cirque, its terminations culminating in two horn-like peaks. This occupies the upper third of the cliff, the middle third is precipitous rock, the lowest talus. On the left bank the mountain slopes are steep. A peculiar dome-shaped hill, the Beehive, 7,350 feet, and ridge, a continuation of the same, form the right bank of Lake Agnes and overlook the left bank of Lake Louise. The shape of the lake is modified by talus, but there is no possibility of hidden outlet, nor can we find sign of glacial deposits. The opening of this sack-shaped valley, with its tiny lake, is wide, and formed of thickly bedded quartzite. The outflow stream is nearer the left bank of the lake, and the rock floor slopes gently down to it. A shallow groove has been worn away in the quartzite, and the discharge stream empties as a small waterfall into Mirror Lake below. The latter is rather less satisfactory from the geologist's point of view. It is circular in shape and about 150 yards in diameter for the most part, no doubt surrounded by live rock, but modified in shape by talus and quite possibly by some glacial deposits. Whether the latter have dammed the exit is

[1] Canada Geol. Surv., 1886, N.S., vol. ii, p. 310.

[2] "A Type of Lake Formation in Canada": Journ. Geol. Chicago, vol. vii (1899), p. 253.

difficult to say, unless soundings were taken, but live rock (quartzite) outcrops on the trail leading down to Lake Louise, not far below the level of Mirror Lake. No exit stream can be found, and the overflow is said to find its way to Lake Louise by underground channels; a statement I see no reason to doubt, but the fact is unfavourable to the hypothesis that Mirror Lake is a true rock basin.

The valley in which Lake Louise lies, 850 feet below, is clearly blocked at the lower end of the lake by drift, but Wilcox states that the bottom of Lake Louise is 230 feet below the very lowest part of its dam, and the lower surface of its glacier must have ascended this slope upon entering the Bow Valley. It is possible, then, that the lake is a true rock basin.

One other example, also of a dubious nature, remains to be mentioned, viz., that from the Selkirks, near the Great Glacier, and some 1,500 feet above the station of Glacier on the C.P.R., directly overlooking the valley. It is called Lake Marian. Mountains rise abruptly, with talus strewn around their bases for nearly half the circumference of the lake; in front, where the pine-clad slopes plunge down to the valley beneath, a quartzite outcrops. This, or a crushed grit, is the common rock of the ascent from Glacier, with some outcrops of broken silvery slate. On the remaining (eastern) side live rock, if it exists, is concealed by surface soil and undergrowth, and the level is low. At first I thought Lake Marian to be a true rock basin, but subsequent reflection inclines me to the belief that glacial deposits may exist. The slopes on the south-eastern side of the lake in the direction of Mount Abbott are not precipitous, and it is possible that here a glacier left material sufficient to retain the water.

We are left, therefore, with but one clear and certain example of a rock basin, and it remains but to consider as briefly as may be what causes operated in its formation. And firstly, differential earth movements, as suggested by Mr. Brend for the Caernarvonshire tarns, may be considered. The bedding of the rocks forming the walls of the lake is remarkably well defined, and not far removed from the horizontal, but on looking at the right bank from an advantageous position, it becomes apparent that a slight dip up the lake exists which is greater at the lower than at the upper end. As the change, though slight, is abrupt, a small fault probably exists at this point.

The cirque is no doubt pre-Glacial, but it is possible that the configuration of the country has been altered in quite late times. Dr. J. W. Spencer, in his well-known work on the "Origin of the Basins of the Great Lakes in America,"[1] has demonstrated 'terrestrial warpings' more recent than the episode of the Upper Till. On the western side of the continent Dr. G. M. Dawson[2] mentions terraces

[1] Quart. Journ. Geol. Soc., vol. xlvi (1890), p. 530.

[2] "The Superficial Geology of British Columbia": Quart. Journ. Geol. Soc., vol. xxxiv (1878), p. 89. See also Dr. G. M. Dawson, "On the Physiographical Geology of the Rocky Mountain Region in Canada": Trans. Roy. Soc. Canada, vol. viii (1890), sect. 4, p. 68.

on the Fraser and Thompson Rivers in British Columbia, from 2,400 to 3,000 feet. Of these he says: "Many of the higher are accumulations along the shore of a great sheet of water; most of the lower have been carved out of deposits which at one time filled the valleys from rim to rim, and more or less completely levelled up the broken surface of the country, by the gradually receding waters of a lake or of the sea, and eventually by the rivers themselves deepening their channels to their old pre-Glacial levels" (p. 112). He concludes that the interior of British Columbia was submerged 4,000 to 5,000 feet during the formation of the Boulder-clay (p. 108).

The second hypothesis ascribes sufficient erosive power to a glacier in descending a sharp declivity such as the cirque at the head of Lake Agnes. Such plunging action is appealed to by Professor Bonney to explain the rock basins of Lakes Cadagno, Tremorgio, and others on the Lepontine Alps. In the case of Lake Agnes a glance at the map shows that here is ample gathering-ground for ice. The line of the Continental watershed lies a mile and a half to the west, with summits ranging, in the case of Pope's Peak, to 9,595 feet. Mount St. Piran, to the north, has a height of 8,580 feet. These between them form the north and north-north-west walls of the tarn. If any erosive action can be ascribed to ice, the present instance would afford an excellent opportunity for the display of its power, and it is quite possible that this is the true explanation.

At the time of my visit to Lake Agnes a third possibility occurred to me which may have some value, at least, as a contributory cause. The quartzite forms the lower bed in the walls of the lake, and must also occupy its floor, for the little waterfall of discharge passes over it for some distance below the level of the lake surface. The superincumbent beds are of a slaty nature, rather finely bedded, and broken. This, taken in conjunction with the dip of the whole up the lake, seemed to me to make it at least possible that the ordinary agents of denudation in working out the valley and its cirque-like head might form a basin which would retain water, simply from the fact that there was a greater thickness of less resisting material at the upper than at the lower end. I put this on record merely as a suggestion, but we may perhaps suppose some such process as the following. In early days the valley would incline steeply down to its lip, its bottom occupied by a stream attaining at certain times of the year to the dignity of a torrent of some dimensions. When worn down at its lower end to the level of the more resisting quartzite, the erosive action of the water would be checked at that point, but the constant freshets concentrated on its upper end by reason of the cirque-like disposition of the cliff would prevent the removing power of the water being materially lessened at the valley head. This process would go on possibly with increasing slowness, but with a tendency analogous to that ascribed to a glacier in descending a steep slope.

My sincere thanks are due to Professor Bonney for his kindness

in reading the manuscript of this paper, and for many valuable suggestions.

DESCRIPTION OF PLATE VI.

FIG. 1.—Photograph taken from the glacial deposits at the lower end of Lake Louise, and looking towards Lakes Agnes and Mirror. The cirque at the head of the former is well seen. The rounded promontory in front of the cirque is the "Beehive." To the right of this lies Mirror Lake, its position concealed by the upper part of the belt of forest. The point × is the same in both figures.

FIG. 2.—Mirror Lake. The waterfall of discharge from Lake Agnes is the white speck amongst the trees below the mark ×.

II.—A SHORT ACCOUNT OF A BONE CAVE IN THE CARBONIFEROUS LIMESTONE OF THE WYE VALLEY.

By DOROTHY M. A. BATE.

THE bones of Pleistocene mammals and birds, a list of some of which is given below, were found in a small cave in an outlying part of the Forest of Dean, close to the river Wye, where it is flanked by steep and wooded hills that rise abruptly from either bank. At short intervals along the sides of these hills limestone cliffs and boulders stand out bare and white among the surrounding trees. The slopes below are strewn, and in places completely covered, with pieces of rock of all sizes that are continually becoming loosened and fall from the outstanding crags above, in which are numerous cracks, holes, and caves, the last, as a rule, being only of small size.

The mouth of the cave in which these remains were found is situated half-way up the face of one of the cliffs. It is completely concealed from view by a thick growth of trees and bushes. This probably accounts for its being little known and not previously explored for animal remains, though, unfortunately, several human jaw-bones lying on the floor of the cave were taken away by some boys while searching for jackdaws' nests. Some time ago the greater part of the floor was dug up by miners looking for iron-ore. This was a most unfortunate occurrence, as in this way the position of the upper layers of earth and rock forming the floor of the cave has been considerably obscured. At the same time the bones contained in these deposits were mixed, specimens undoubtedly differing greatly in age being found in close proximity; furthermore, some of the bones of species now living bore a very fresh appearance.

The walls of the cave have not been disturbed, for here numerous minute bones are found in a good state of preservation. These were lying even in exposed situations where they might easily have been destroyed. This is perhaps the most curious feature of the cave, for at its inner end on every ledge and in every crevice were found small bones, most of them belonging to one or other of the smaller species of voles and mice. These remains have disappeared from the ledges near the entrance, doubtless on account of exposure to wind and wet, and to the presence of jackdaws, which nest in large numbers in all the cliffs.

The cave consists of two chambers, the larger of which penetrates the cliff for about thirty yards, only decreasing slightly in size from the entrance, which is large. The floor is partially covered with a layer of earth, which in one place is about a foot and a half thick. As already remarked, its original disposition has been more or less altered by the workings of the miners. This earth contained great quantities of small skulls and bones, the commonest among them belonging to *Microtus agrestis* and *M. amphibius*.

Owing to lack of time I was unable to penetrate below this earth except where some of the rock had already been removed. Portions of the walls several feet above the present level of the floor are encrusted with numberless small bones, impossible to extract in good condition owing to the hardness of the limestone. If pieces of rock were broken away similar bones were certain to be found loose in any soft or crumbly places. In fact, they were plentiful throughout the cave—in the earth, on the ledges, in the walls, and even on the surface of the floor. The bones embedded in the rock, as well as those concealed in the earth, were found extending right up to the mouth of the cave. These must have accumulated at a time when the cave was considerably larger than it now is. This it undoubtedly was at one time, for, as the face of the cliff has gradually been worn away, the slope below has become strewn with fragments of rock of all sizes. Another proof of this is that in its present state it would be impossible for such animals as sheep and deer to reach the cave. Yet the bones of these animals, and of others for whom it would be as difficult of access, are found buried in the earth. It is now evidently inaccessible to foxes and badgers, as there are no holes used by them here, although they are to be seen in almost every other cave I have visited in the district.

The smaller chamber opens into the main cave near the inner end of the latter, and runs almost parallel with it towards the face of the cliff. It has now no direct connection with the outside, although there is an opening in the cliff with which it was probably formerly connected. It is possible that the present entrance has only lately been made. The roof is very low, forcing one to crawl on hands and knees. Part of the floor has been disturbed in the same way as in the outer chamber, but, unlike it, there is little of the earth in which the greater number of the small bones were found. Probably the real mouth of this cave has been closed up by the roof at this point giving way, the rock having been loosened by water. At the end nearest the face of the cliff there is always a certain amount of water to be seen dripping from the wall. The rock over which it runs down to the level of the floor has been formed into a series of ridges, somewhat resembling those left on the sand by the receding tide, though they differ in being higher and sharper and closer together. This has a very striking appearance when a light is thrown on its ribbed surface, which looks black and highly polished, and is always glistening with moisture. Wherever this water penetrates it leaves a deposit of stalagmite, which causes the rock to become

extremely hard, thus making any excavation a difficult task, and in some places it is impossible to detach bones from the rock intact.

The cave contained the teeth and jaw-bones of six small mammals that are now extinct in Great Britain. These are: *Microtus ratticeps*, *M. arvalis*, *M. nivalis*, *Lemmus lemmus*, *Dicrostonyx* (=*Myodes*) *torquatus*, and *Ochotona* (=*Lagomys*) *pusillus*. At the present day these species are found chiefly in colder and more northern countries, the pika being confined to the steppe regions of Eastern Europe and Siberia. No remains of the reindeer or other large northern forms were found, though from the presence of the lemmings and some of the voles this might have been expected. Remains of the reindeer and mammoth have been taken from a somewhat similar cave situated not two miles distant. See British Museum (Natural History) Coll.

Remains of the following animals were found in this cave:—

Homo.—I have already mentioned that some jaw-bones were found on the floor of the cave, but I have been unable to secure one or to trace their present whereabouts. I procured one clavicle, several vertebræ, and a number of digital phalanges. The only implements found were a bone needle, or hairpin, and a portion of a copper ring.

Bone needle, one-third less than original specimen.

The needle, which Sir Henry Howorth considers belongs to the Bronze Age, is a very fine specimen in a perfect state of preservation. It is five inches in length and has a circular hole pierced through its broader end, from which it gradually tapers to a blunt point. The larger end has the appearance of having been cut straight across with some sharp instrument.

Rhinolophus hipposideros.—Two lower jaw-bones and a portion of one skull of this bat were among the remains found in the cave.

Talpa Europæa.—One upper jaw of this species and two mandibular rami were found in the cave together with several pelvic bones. There is a considerable difference in the size of these two rami, one of which, the larger, still retained a milk tooth. Fossil remains of this mole have been found in the Norfolk Forest Bed as well as in Pleistocene deposits. Mr. W. J. Lewis Abbot found numerous bones belonging to this species in the Ightham fissure in Kent.

Sorex araneus.—The upper jaws of the common shrew were fairly plentiful, one or two skulls being found in an almost perfect state of preservation. They varied much in size, a considerable difference being noticeable between the largest and the smallest specimens obtained. The lower jaw-bones were less numerous; perhaps on account of their small size they were easily passed over when buried in the earth. Less than half a dozen were secured, all of them retaining their full number of teeth. Remains of this shrew have been found in the Forest Bed and in caves.

Neomys **(= *Crossopus*) *fodiens*.**—One upper jaw of the water-shrew was found which still retained its full number of teeth. Its remains have occurred in the Norfolk Forest Bed.

***Microtus amphibius*.**—Jaw-bones and portions of skulls of the water-vole were numerous in the cave earth. Many of the rami were preserved in an almost perfect condition. Its remains have been found in Pleistocene deposits and in a number of caves in England.

***Microtus agrestis*.**—Remains of the field-vole were more plentiful than those of any other of the species found in the cave. Similar remains have been found in many caves in England. This vole is still living in Britain and extends over the middle and north of Europe, being commoner in the northern part of its range.

Microtus ratticeps*.**—One or two portions of skulls and about a dozen rami of the northern vole were found in this cave, and agree with recent specimens in the British Museum. In a few of the lower jaw-bones the teeth resemble the figure of ***M. gregalis given by Dr. Nehring in a paper published in 1875, but the presence of intermediate forms between this and the typical ***M. ratticeps*** makes it probable that all in this series ought to be referred to the latter species. Fossil remains of ***M. ratticeps*** have been found in England in the river deposit at Fisherton, in caves in Somersetshire, and in the Ightham fissure in Kent. It no longer occurs in Great Britain, but is now found in Northern Europe and Siberia.

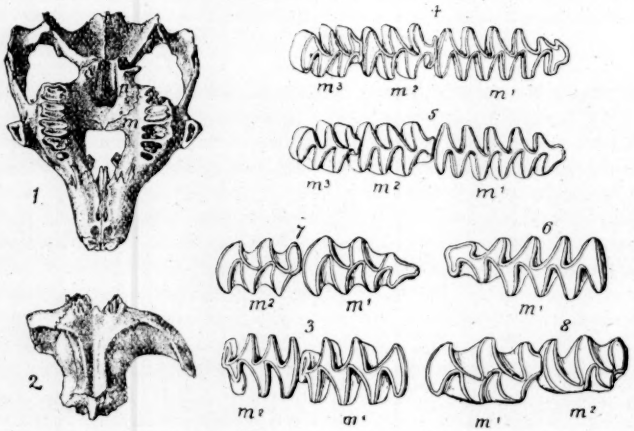


FIG. 1.—Palatal view of skull of *Ochotona* (*Lagomys*) *pusillus*.
FIG. 2.—Dorsal aspect of part of skull of *Dicrostonyx* (*Myodes*) *torquatus*.
FIG. 3.—View of upper molars of *Dicrostonyx* (*Myodes*) *torquatus*.
FIGS. 4–6.—View of lower molars of *Dicrostonyx* (*Myodes*) *torquatus*.
FIGS. 7, 8.—View of (7) lower and (8) upper molars of *Lemmus* (*Myodes*) *lemmus*.

Microtus arvalis*.**—Several jaw-bones, upper and lower, may be referred to this species. Their upper teeth are easily distinguished from those of ***M. agrestis by the character of the second molar, but the lower teeth of these two species resemble each other very closely.

Remains of this field-vole have been found in the Forest Bed and in fissures near Frome and at Ightham. It is no longer living in Great Britain, but is the commonest field-vole of Central Europe, its range extending as far as Western Siberia.

Microtus nivalis.—Two mandibular rami, which I have compared with recent specimens in the British Museum, are referred to this species. A third might possibly also belong to this vole, but is too imperfect to admit of certain identification. At the present day it is not found in Britain, but inhabits the Alps of Central Europe, where it is not found at a lower elevation than 3,000 feet above the sea-level. By Dr. Selys Longchamps it is said to occur in the Pyrenees, and may possibly also be found elsewhere. The only record of the fossil remains of this species being found in England is that of Messrs. Blackmore and Alston, who doubtfully referred to this species a jaw-bone found in the river deposit at Fisherton, near Salisbury (P.Z.S., June, 1874).

Evotomys (= *Microtus*) *glareolus.*—Part of one skull and several mandibular rami of the bank-vole were found in the cave earth. In one or two of the rami, which belonged to immature animals, the teeth had not yet developed roots. Its remains have been found in the Forest Bed, in many caves, and in Pleistocene river deposits. At the present day its range extends to the Arctic circle.

Lemmus (= *Myodes*) *lemmus.*—Portions of five upper jaws of the Norwegian lemming were found in the earth together with eight lower jaw-bones, only one of which contained the full number of teeth. This species is no longer found in Britain, its range at the present day being confined to the Scandinavian peninsula and Russian Lapland. Its remains have been found in a cave in Somersetshire and in the Ightham fissure in Kent.

Dicrostonyx torquatus.—Nearly a dozen well-preserved mandibular rami of this species were found, but only a portion of one upper jaw. The Arctic lemming occurs in the Pleistocene of England and the Continent, but is now entirely confined to the Arctic regions.

Ochotona (= *Lagomys*) *pusillus.*—Portions of eight or nine skulls of this species were found together with nineteen lower jaw-bones. The remains of this tailless hare are interesting, as no representative of the family is found in the British Islands at the present day. This pika now only inhabits Eastern Russia and Siberia. Its fossil remains have been procured from several other caves in England: at Bleadon, Brixham, and Kent's Hole.

Lepus timidus (*L. variabilis*).—Portions of a skull and lower jaws, both retaining teeth, are referred to this species. Remains of the mountain hare have been found in several caves, in the Mendip Hills, and at Knockninny and Shandon in Ireland.

Mus sylvaticus.—Eighteen lower jaw bones and portions of about seven or eight skulls are referred to this species, which is still found widely distributed over temperate Europe, and extending to Western Siberia and the Caucasus. Its remains have been found in the Forest Bed and at West Runton, Norfolk.

A great number of small limb bones, most of which probably

belong to the small rodents, were found scattered over the cave and buried in the earth with the other remains. Some other remains are referred to the dog, sheep (which appears to have been considerably smaller than the ordinary domestic variety), a species of small deer, several bones of *Rana temporaria*, and three snail shells, probably *Helix hortensis*. Dr. Andrews kindly identified the remains of birds found in the cave. They belong to five species, remains of all of which have occurred in other caves in Britain. They are *Turdus* sp., probably *Turdus viscivorus*, pigeon sp., *Anas boschas*, *Lagopus scoticus*, and *Perdix perdix*.

I wish to express my thanks to Dr. Andrews and Dr. Forsyth Major for the very kind and valuable help I have received from them, especially in assisting me to determine the extinct forms, and also for Dr. Forsyth Major's kind advice in selecting those which have been figured in the text.

III.—Woodwardian Museum Notes: Salter's Undescribed Species. III.

By F. R. Cowper Reed, M.A., F.G.S.

(PLATE VII.)

Phacops (*Odontocheile*) *caudatus*, var. *corrugatus*, Salter. (Pl. VII, Figs. 1, 2.)

1873. Salter: Cat. Camb. Sil. Foss. Woodw. Mus., p. 93 (*a* 461).

There are six specimens of this variety in the Woodwardian Museum, all of which come from the Woolhope Limestone, of Littlehope, and were labelled by Salter. Five of them are more or less perfect head-shields, and the other is a pygidium in a good state of preservation.

The head-shield shows the general characters of *Ph. caudatus*, var. *a*, *vulgaris*,[1] but the arrangement of the tubercles on the frontal lobe of the glabella is peculiar, and resembles that of *Chasmops*, for they form a V-shaped pattern, six or seven large tubercles composing each arm of the V. The arms of the V enclose an angle of about 30° to 40°. A few other large tubercles occur on the frontal lobe close to the V, and starting from its apex show an obscure radial arrangement. The margin of the head-shield, where the shell is preserved, exhibits an ornamentation consisting of closely-set, rather coarse granulations. The front margin is produced into an obtuse point.

The main characters of the pygidium are similar to those of the typical variety of *Ph. caudatus*. The axis, however, shows ten distinct rings with a less distinct eleventh one, and a short, faintly annulated, terminal piece. The rings are less strongly defined in the middle, owing to the transverse furrows being comparatively weak in the middle while deeply impressed at the sides.

On the fourth and seventh axial rings is a pair of small oval areas, slightly raised above the general surface and finely pitted (the so-called 'cutaneous glands' of Salter, op. cit.). There are faint

[1] Salter: Mon. Brit. Trilob. Pal. Soc., 1864, p. 51.

traces of similar 'glands' on several of the other rings. The whole axis, as well as the lateral lobes, is also ornamented with minute pits.

The lateral lobes show seven distinct pairs of pleuræ, ending abruptly on the smooth narrow margin, but separated by strongly raised ridges. The surface of each pleura is excavated, and bears a furrow, in front of which the surface is sharply ridged up. The furrow is close to and nearly parallel to the posterior edge of the pleura. On the ridge along the anterior edge of the furrow on each pleura, there is a so-called 'cutaneous gland' situated similarly to those figured by Salter[1] for *Ph. caudatus*. On the first pleura this gland is near the axis; on the second it is near the outer extremity; on the third it is placed half-way along the length of the pleura; and on the fourth it is near the axis. Those on the fifth, sixth, and seventh pleuræ repeat the arrangement of the second, third, and fourth. A few tubercles are also found scattered irregularly over the lateral lobes. The pygidial margin was produced posteriorly into an aculeate mucro, but it is broken off short in our specimen.

MEASUREMENTS.

	mm.
Length of pygidium	22·0 (*minus* mucro).
Width of ditto	24·0
Width of axis of pygidium (at front end) ...	8·5
Length of ditto	18·0

AFFINITIES.—Lindström's species *Ph. obtusa*,[2] from the Gotland beds, bears comparison with this variety of *Ph. caudatus*, but though the furrowing of the glabella is closely similar, the V-shaped arrangement of the tubercles seems to be absent and also the 'cutaneous glands' on the pygidium. The true significance and function of these so-called glands is at present unknown, but, if we may presume on our scanty knowledge of these structures to make a suggestion, they appear to be similar to the maculæ on the hypostomes of most trilobites which Lindström[3] after a detailed study has recently concluded had a visual function. It may be that these pygidial structures were organs of phosphorescence.

ENCRINURUS MULTIPLICATUS, Salter. (Pl. VII, Fig. 3.)

1873. *Encrinurus multiplicatus*, Salter: Cat. Camb. Sil. Foss. Woodw. Mus., p. 51 (*a* 226).
1891. *Encrinurus multiplicatus*, Salter (Woods): Cat. Type Foss. Woodw. Mus., p. 144.

The original specimen is very imperfect, and consists of only a partially preserved pygidium, so that the description of this species must be somewhat incomplete. It is labelled as having been found in the Middle Bala at Barking, Dent, and is preserved in a tough dark-grey limestone. The pygidium has an elongated and pointed form somewhat like *E. multisegmentatus* (Portl.), and possesses

[1] Salter: Mon. Brit. Trilob. Pal. Soc., 1864, p. 52, woodcuts 11 and 12.
[2] Ofv. k. Vet. Akad. Förhandl., No. 6, 1885, p. 41, pl. xii, figs. 3, 4, 7, 8, and pl. xiii, fig. 1.
[3] Kongl. Svensk. Vet. Akad. Handl., B. 34, No. 8, 1901.

a long narrow axis tapering very gradually to its posterior extremity. There are sixteen complete axial rings of gradually decreasing size, extending for about two-thirds the length of the axis, and followed by about twelve much narrower rings of equal size, interrupted in the middle by a narrow smooth area, and extending to the point of the axis, which is thus segmented along its whole length.

Only one of the lateral lobes is preserved, but this shows the eleven pleuræ of which it is composed, and is bent down rather strongly towards the posterior end. The anterior pleuræ curve weakly backwards, but the posterior ones more strongly, and the last one, which starts at the level of the sixteenth axial ring, runs back alongside of the axis to the posterior margin. Each pleura appears to be provided with a shallow median longitudinal furrow.

There are obscure traces of small tubercles on the surface, but the ornamentation is very indistinct.

MEASUREMENTS.

	mm.
Length of pygidium	12·0
Width of ditto ... ... (estimated at)	10·0

AFFINITIES.—The most closely allied species might appear at first sight to be *E. multisegmentatus*, Portlock,[1] but the resemblances lie more in the large number of the segments than in the characters of the parts of the pygidium. For the segmentation of the axis is different, and the course of the pleuræ is not the same. The segmentation of the posterior part of the axis more resembles that of *E. punctatus*, though the anterior part with its complete rings is quite different, and is similar to that in Portlock's species. As far as the axis is concerned, it thus seems to share the characters of these two species.

Turrilepas ?? *ketleyanus*, Salter.

1873. *Turrilepas ketleyanus*, Salter: MS. Cat. Camb. Sil. Foss. Woodw. Mus., p. 129 (*b* 730).
1891. *Turrilepas ketleyanus*, Woods: Cat. Type Foss. Woodw. Mus., p. 132.

The two original specimens are very poorly preserved and fragmentary and the plates seem to be displaced from their original position, and the description, therefore, is far from satisfactory. The specimens are from the Wenlock Limestone of Dudley, and were presented to the Woodwardian Museum by Mr. C. Ketley.

DIAGNOSIS.—Two vertical rows of loosely arranged, alternating plates of regular (?) shape, followed above by a closely imbricated mass of irregular plates. There are four or five plates in each of the vertical rows, but their shape is somewhat doubtful, as their edges appear to be broken in most cases, but they seem to be transversely oblong (not triangular), with their upper and lower edges sub-parallel, and the outer edge rounded; they are also slightly arched from side to side, and their surface is marked by fine striæ parallel to the outer edge and by minute pits and granulations.

[1] Portlock: Geol. Rep. Lond., 1843, p. 291, pl. iii, fig. 6. Törnquist: Undersokn. Siljans. Trilobitf., 1884, p. 24, pl. i, figs. 18, 19.

In the upper mass of closely packed plates only the minute pits and granulations are visible. These upper plates appear to be triangular and to bear a carina.

Remarks.—It is extremely doubtful if this fossil is the remains of a crustacean, and it has been suggested with much probability that it represents the column of one of the Anomalocystidæ.[1] The supposed shape of the plates in the double row cannot be regarded as of much value, owing to their imperfect condition. It is unfortunate that Salter chose to attach a specific name to such exceedingly unsatisfactory specimens.

GASTEROPODA.

Subulites pupa, Salter. (Pl. VII, Fig. 5.)

1873. *Macrocheilus pupa*, Salter: Cat. Camb. Sil. Foss. Woodw. Mus., p. 156 (*a* 869).
1891. *Macrochilina pupa*, Woods: Cat. Type Foss. Woodw. Mus., p. 106.

There is one specimen in the Woodwardian Museum from the Wenlock Limestone of Dudley (Fletcher Collection), labelled *Macrocheilus pupa* (*a* 869) by Salter. Only the three lower whorls are preserved, and these show no ornament; the two apical whorls are broken off. The shape of the mouth is also well seen. The regular, elongate, fusiform shell, the shallow suture-line, the slight convexity of the whorls and their want of ornamentation, the large body-whorl, equal in length to about half the shell, and the narrow elongate aperture, inferiorly acuminate, show that it is comparable to *Subulites ventricosus* (Hall),[2] described and figured also from the Wenlock of Sweden by Lindström.[3] It cannot be assigned to the genus *Macrochilina*, on account of the shape and characters of the mouth and the shallowness of the suture-line. This species has also been found by Professor Hughes in the Lower Llandovery of Blain y cwm.

Measurements.

	mm.
Length of specimen	35·0
Estimated length when perfect	40·0
Width of body-whorl	18·0

Trochus calyptræa, Salter. (Pl. VII, Fig. 4.)

1873. *Euomphalus calyptræa*, Salter: Cat. Camb. Sil. Foss., p. 157 (*a* 862).
1891. *Euomphalus calyptræa*, Woods: Cat. Type Foss. Woodw. Mus., p. 103.

The one small original specimen (*a* 862) from the Wenlock Limestone of Dudley is all the material we possess. It is imperfect, but the body-whorl is well preserved and shows the essential features.

Diagnosis.—Shell small, trochiform, obtusely conical, of several whorls (probably four or five), which are sub-ventricose. The body-whorl has an angulated, rather prominent umbilical edge, and its umbilical surface is flattened at right angles to the rest of the whorl,

[1] H. Woodward: Geol. Mag., Dec. II, Vol. VII (1880), p. 193, Pl. VI, and Woodcut, Fig. 6, p. 197.
[2] Hall: Pal. N.Y., ii (1852), p. 347, pl. 83, fig. 7.
[3] Lindström: Sil. Gastr. Pter. Gotl., 1884, pp. 193, 194, pl. xv, figs. 19–21.

slightly raised in the centre and more so towards the aperture, which appears to be subcircular, with the inner lip strong and thickened. Surface of whorls ornamented by transverse, obliquely curved, regular, and equidistant lamellar ribs. Umbilicus small and apparently closed.

Remarks.—This form certainly does not belong to the genus *Euomphalus*. Its whole appearance is trochiform, and it bears a close resemblance to *Trochus Stuxbergi* (Lindström),[1] but differs by the umbilical surface being flatter, by the marginal ridge being less developed, and by the greater strength and regularity of the growth-lamellæ on the surface. Its ornamentation is not so coarse as in *Tr. undulans* (Lindström),[2] but the shape of this species and its umbilical surface are very similar. The characters of the mouth and umbilical surface distinguish it from *Callonema obesum* (Lindström),[3] with which at first sight it bears some resemblance in shape and ornamentation.

EXPLANATION OF PLATE VII.

Fig. 1.—*Phacops* (*Odontocheile*) *caudatus*, var. *corrugatus*, Salter. Head-shield (*a* 481), × 1½. Woolhope Limestone, Littlehope.
Fig. 2.—Ditto. Pygidium (*a* 461), × 2. Woolhope Limestone, Littlehope.
Fig. 3.—*Encrinurus multiplicatus*, Salter. Pygidium (*a* 226), × 3. M. Bala, Barking, Dent.
Fig. 4.—*Trochus calyptræa*, Salter sp. (*a* 862), × 2. Wenlock Limestone, Dudley.
Fig. 5.—*Subulites pupa*, Salter sp. (*a* 869), × 1½. Wenlock Limestone, Dudley.

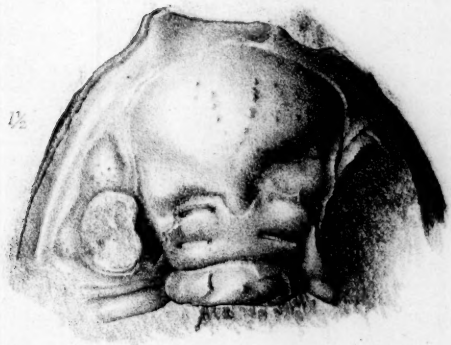
IV.—Notes on the Lower Carboniferous Fishes of Eastern Fifeshire.

By Dr. R. H. Traquair, F.R.S., F.G.S.

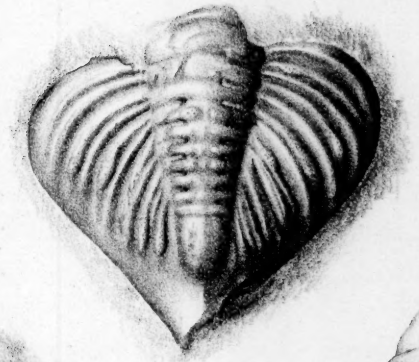
(Read before the Royal Physical Society of Edinburgh, January 16th, 1901.)

Not much has as yet been done in the way of cataloguing the fossil fishes of the Lower Carboniferous rocks of Eastern Fifeshire. A few species and localities were noted by the late Rev. Thomas Brown in 1860[4] and by Mr. Kirkby in 1880,[5] and the late Mr. Robert Walker published a paper in 1872[6] in which he described what he supposed to be a new species of *Amblypterus* (*A. anconoæchmodus*) from the Oil-shale works at Pitcorthy, near Anstruther. In this paper Mr. Walker drew attention to the abundance and variety of fish-remains in the oil-shale and ironstone worked at that locality, promising to describe them in detail afterwards—a promise which he was never able to fulfil. After his

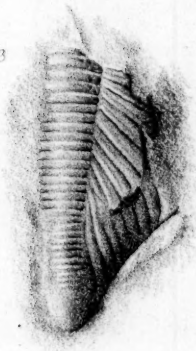
[1] Sil. Gastr. Pter. Gotl., p. 147, pl. xiv, figs. 59–69 (especially fig. 62).
[2] Op. cit., p. 148, pl. xvi, figs. 8–10.
[3] Op. cit., p. 189, pl. xv, fig. 27.
[4] "Notes on the Mountain Limestone and Lower Carboniferous Rocks of the Fifeshire Coast from Burntisland to St. Andrews": Trans. Roy. Soc. Edinb., vol. xxii (1860), pp. 385–404.
[5] "On the Zones of Marine Fossils in the Calciferous Sandstones of Fife": Quart. Journ. Geol. Soc., vol. xxxvi (1880), pp. 559–590.
[6] "On a new species of *Amblypterus* and other Fossil Fish-remains from Pitcorthy, Fife": Trans. Geol. Soc. Edinb., vol. ii, pt. 1, pp. 119–124, with plate.



1 × 1½



2 × 2



3 × 3

5 × 1½

4 × 2

G.M.Woodward del. et lith. West, Newman imp.

Ordovician and Silurian Fossils.

death in 1881, his important collection of fish-remains from this and other localities in East Fife was acquired by the Edinburgh Museum, and largely forms the basis of the present list. I myself have also done some collecting in this region; and a good many years ago the Museum acquired a number of specimens collected by Mr. W. T. Kinnear at Ardross, some of which are of great interest.

The district in question is comprised in sheets 41 and 49 of the Geological Survey Map of Scotland. All the species here noted are from Lower Carboniferous rocks, the horizons represented being the Upper part (Oil-shale group) of the Calciferous Sandstone Series and the Lower part of the Carboniferous Limestone Series. Here I may note that in 1890[1] I included the Teleostomi and Dipnoi of the region in a list of the fishes of these orders occurring in Fife and the Lothians, published by the Royal Society of Edinburgh. The present list, however, includes the Elasmobranchs as well, and also a few additional species now described as new.

CALCIFEROUS SANDSTONE SERIES.

Elasmobranchii.

1. *Pleuracanthus horridulus*, Traq. Pitcorthy.
2. *Diplodus parvulus*, Traq. Pitcorthy.
3. *Cladodus unicuspidatus*, Traq., n.sp. Near Rock and Spindle.
4. *Callopristodus pectinatus* (Ag.). Rocks east of St. Andrews; Pitcorthy.
5. *Oracanthus armigerus*, Traq. Teeth, at Ardross.
6. *Gyracanthus*, sp. Rocks east of St. Andrews; Pittenweem. Not sufficiently well preserved for specific determination.
7. *Sphenacanthus serrulatus* (Ag.). Pitcorthy.
8. *Sphenacanthus Fifensis*, n.sp. Rocks east of St. Andrews.
9. *Euphyacanthus semistriatus*, Traq. Ardross.
10. *Tristychius arcuatus*, Ag. Pitcorthy.
11. *Tristychius minor*, Portlock. Pitcorthy.
12. *Cynopodius crenulatus*, Traq. Pitcorthy.
13. *Acanthodes sulcatus*, Ag. Ardross.

Teleostomi.

Crossopterygii.

14. *Rhizodus Hibberti* (Ag.). Rocks on shore east of St. Andrews; Pitcorthy.
15. *Rhizodus ornatus*, Traq. Pitcorthy; Pittenweem.
16. *Strepsodus striatulus*, Traq. Pittenweem.
17. *Strepsodus minor*, Traq. Pitcorthy.
18. *Cœlacanthopsis curta*, n. g. and sp.

Actinopterygii.

19. *Elonichthys Robisoni* (Hibbert). Pitcorthy.
20. *Elonichthys striatus* (Ag.). Pitcorthy.
21. *Elonichthys pectinatus*, Traq. Ardross.
22. *Rhadinichthys ornatissimus* (Ag.). Kiness Burn, near St. Andrews.
23. *Rhadinichthys carinatus* (Ag.). Pitcorthy; Corn Ceres, near Kilrenny.
24. *Rhadinichthys brevis*, Traq. Pitcorthy.
25. *Nematoptychius Greenocki* (Ag.). Pitcorthy.
26. *Gonatodus punctatus* (Ag.). Pitcorthy. This is the *Amblypterus anconœchmodus* of R. Walker.
27. *Eurynotus crenatus*, Ag. Pittenweem; Pitcorthy; Corn Ceres; Kenly Mouth, east of St. Andrews.

[1] "List of the Fossil Ganoidei and Dipnoi of Fife and the Lothians": Proc. Roy. Soc. Edinb., vol. xvii (1890), pp. 385–400.

DIPNOI.

28. *Ctenodus interruptus*, Barkas. Pittenweem.

INCERTA SEDIS.

29. *Eucentrurus paradoxus*, n. g. and sp. Ardross.

CARBONIFEROUS LIMESTONE SERIES.

ELASMOBRANCHII.

1. *Petalodus acuminatus*, Ag. Ladedda, near St. Andrews.
2. *Oracanthus armigerus*, Traq. Largo Ward.
3. *Sphenacanthus serrulatus*, Ag. Denhead Ironstone, Denhead, near St. Andrews.
4. *Acanthodes*, sp. Denhead.

TELEOSTOMI.

Crossopterygii.

5. *Rhizodus Hibberti* (Ag.). Denhead.
6. *Rhizodus ornatus*, Traq. Denhead.
7. *Megalichthys*, sp. Denhead.
8. *Elonichthys Robisoni* (Hibbert). Denhead.
9. *Elonichthys pectinatus*, Traq. Denhead.
10. *Eurynotus crenatus*, Ag. Denhead.

The above list contains all the species, thirty in number, which are contained in the Natural History Department of the Edinburgh Museum or in my own collection. Mr. Kirkby, however, records *Ctenacanthus*, sp., from near the Rock and Spindle, and *Pœcilodus obliquus*, Ag., from a marine limestone of Calciferous Sandstone age on the coast near Randerston Castle.

NOTES ON SPECIES.

Diplodus.—I have found small *Diplodus*-teeth in shales on the shore at Pittenweem, but which can hardly be safely identified with any known form or considered as new.

Cladodus unicuspidatus, n.sp.—Base flat below, depth from back to front about two-thirds the width from side to side, contour more convex in front than behind. A single slender pointed cusp arises from the middle of the front of the base, and is erect, straight when seen from the front, sigmoidally recurved when viewed laterally, covered with delicate raised ridges, which increase in number downwards by intercalation. No trace of lateral cusps. Height of cusp of most perfect specimen $\frac{3}{16}$ inch, width of base laterally about the same.

Under the term *Monocladodus*, Professor Claypole[1] has separated from *Cladodus*, Agassiz, two species from the Cleveland shale, on account of the apparent want of lateral cusps. Allied to *Cladodus*, and also possessing only one cusp, are *Lambdodus* and *Hybocladodus* of St. John and Worthen.[2] The present teeth, however, agree so closely with *Cladodus* in all respects, save the want of lateral cusps and the comparatively short lateral extent of the base, that I prefer leaving them with that genus for the present.

A cluster of these teeth was found by myself many years ago in a septarian nodule on the shore near the Rock and Spindle, east

[1] American Geologist, vol. xi (1893), p. 329.
[2] Geol. Surv. Illinois, vol. vi.

of St. Andrews. Owing to the hardness of the matrix it was impossible to work out the superficial configuration of the teeth, except in two instances where they happened to be covered by white carbonate of lime.

Sphenacanthus Fifensis, n.sp. — Length of the largest specimen, $5\frac{3}{4}$ inches; greatest antero-posterior diameter, $\frac{3}{4}$ inch; implanted portion reaching up to $1\frac{3}{4}$ inches in front and $2\frac{3}{4}$ inches behind; form straight and tapering; posterior area slightly concave, its margins showing traces of abraded denticles; anterior margin of exserted portion formed by a sharp median ridge; sides ornamented by straight ribs or rounded ridges, which increase in number proximally by bifurcation, and are not nodose.

This spine, of which there are several specimens in the Walker Collection, Edinburgh Museum, differs from *Sph. serrulatus*, Ag., by the multiplication of the lateral ribs by bifurcation instead of intercalation. The want of nodosity of these ribs is of no consequence, as the greatest difference occurs in this respect in different individuals of *Sph. serrulatus*, and also of the closely allied Coal-measure form *Sph. hybodoides* (Egerton). In a hard calcareous sandstone from the coast east of St. Andrews.

Cœlacanthopsis curta, n. g. and sp.—Of this interesting fish only one specimen has been obtained, and that one is unfortunately deficient at the caudal extremity. What remains measures 2 inches in length, and in this the length of the head is contained three times, being also equal to the greatest depth. The head bones are crushed and scarcely decipherable. Vertebral axis notochordal; abdominal region extending for $\frac{1}{2}$ inch behind shoulder-girdle; no ribs are seen, but there is distinct evidence of the ossified air-bladder characteristic of the Cœlacanthidæ. Neural arches united with the neural spines, which are long, very slender, and closely placed; hæmal arches and spines similar in condition and configuration. On the dorsal aspect and just above the termination of the abdominal cavity a set of slender interspinous bones commences, these being short at first but rapidly increasing in length, until they are as long as the neural spines, and then the fish suddenly breaks up about 2 inches from the tip of the snout. Attached to the distal extremities of these interspinous bones are fin-rays, very short anteriorly, and still short at the point of truncation of the specimen. It is probable that similar elements existed on the hæmal aspect of the skeleton, but have been lost. Paired fins not preserved, except a few imperfect rays where the ventrals ought to be. Indications of the presence of scales feeble.

Strikingly new as this little fish is specifically, a word or two must be said as to its family and generic relationships. The ossified air-bladder and the configuration of its neural and hæmal arches and spines at once indicate that its family position is in the Cœlacanthidæ, but its differences from any known genus of this family are very strongly marked. We have, firstly, the abbreviated form of the fish, which is certainly not entirely due to *post-mortem* shortening up, as the skeletal parts in front of the place where the specimen

is truncated lie nearly quite undisturbed; secondly, the great proportional length of the neural and hæmal spines; thirdly, the apparent absence of the two separate dorsal fins with their compound supporting 'axonosts,' characteristic of the Cœlacanthidæ. These *may* have been lost in the present specimen, but the tips of the neural spines come so close up to the dorsal margin that there would not have been room for the last-named elements if of the form prevalent in the genera of this family. Fourthly, the median fin which we see beginning just opposite the posterior termination of the abdominal cavity corresponds, in its relation to its supporting elements, to the caudal of *Cœlacanthus*, but is immensely further forward in its commencement. It is unfortunate that, owing to the truncation of the fish shortly after the commencement of this fin, we cannot see the extremity of the tail, but enough is shown in the specimen to prove its novelty, both specific and generic. The acquisition of more perfect specimens is, however, urgently to be desired, as it is clear that if the dorsal fins with their compound axonosts are really wanting in this form a change must be made in the received definition of the Cœlacanthidæ, as well as of the Actinistian group of the Crossopterygii.

From Ardross, collected by Mr. W. T. Kinnear, and now in the Edinburgh Museum.

Eucentrurus paradoxus, n. g. and sp.—This extraordinary little organism measures $2\frac{3}{8}$ inches in length, of which $\frac{1}{2}$ inch may be allotted to the head, $\frac{3}{4}$ inch to the body, and $1\frac{1}{8}$ inch to the tail. The head is a mass of calcareous matter, in which something suggestive of a broad curved mandible can be seen, but admits of no further description. The body, $\frac{3}{8}$ inch broad in front, is composed of a greyish film, which when examined by a strong lens is seen to consist entirely of minute, slender, slightly curved, and sharply pointed spinelets. The tail is tapering in form, consisting of amorphous-looking calcareous matter, but on each side (assuming that the creature is crushed vertically) is a conspicuous row of double spinelets arranged exactly opposite each other. From a common base arise two spinelets, which are placed close together and nearly parallel to each other; one of them, the anterior, being only half the length of the posterior one, which just behind the body may attain a length of $\frac{1}{16}$ inch, though towards the end of the tail they become smaller; both of the spinelets are slender, slightly curved, round in transverse section, smooth externally, sharply pointed, and traversed internally by a central tubular pulp cavity. No trace either of internal skeleton, or of limbs, or fins of any sort can be seen.

This strange organism is another of the problems of Palæozoic ichthyology, as it is scarcely possible to indicate its systematic position with any degree of certainty. The nature of its dermal armature would incline us to the belief that it is a Selachian, though all other evidence to that effect is wanting.

From Ardross, collected by Mr. W. T. Kinnear, and now in the Edinburgh Museum.

V.—History of the Sarsens.

By Professor T. Rupert Jones, F.R.S., F.G.S., etc.

(*Concluded from p.* 59.)

II. (8) *Kent.*—1862. Mr. W. H. Bensted, in the *Geologist*, vol. v (1862), pp. 449, 450, states: "The Druid Sandstone, of which Kit's Coty House, Stonehenge, and many other Druidical remains are composed, is found scattered in great blocks over the surface of the Chalk Hills, or buried superficially in beds of clay retained in the hollows on the summits of the escarpments." These stones, he added, are the same as the Greywethers of Berks and Wilts; and are occasionally pebbly, like the Hertfordshire Puddingstones.

1872. In Fergusson's "Rude Stone Monuments," 1872, pp. 116–120, some of the best specimens of Sarsens that remain as relics of prehistoric monuments in Kent are noticed, especially those near Aylesford, on the Medway.

1894. Thomas Wright, in his "Wanderings of an Antiquary, chiefly in the track of the Romans in Britain," 1894, pp. 176–178, describes in detail some large circular pits that have been filled with flints and capped with broad Sarsens, on Aylesford Common; these, he thought, were probably sepulchral, and may have had a chamber opening out of the side at the bottom.

1900. Some small Sarsens from the gravel of the Darent at Shoreham, in Kent, show many perforations of rootlets.—R. A. B.

(9) *Surrey.*—1814. T. Webster: Trans. Geol. Soc., vol. ii, pp. 224, 225. At Pirbright, Surrey, loose blocks of stone similar to what have been called Greywethers. Many loose masses of this rock lie scattered on the surface of the Chalk country, particularly in Berkshire and Wiltshire. Stonehenge chiefly composed of it, and found on the spot. No doubt close resemblance to the siliceous cement of the Hertfordshire Puddingstone.

1847. J. Prestwich. The position of the Sarsen Stones in the Bagshot Sands: Quart. Journ. Geol. Soc., vol. iii, p. 382. In the Lower Bagshot Sands, "a few concretionary masses of saccharine sandstone, which are more compact and harder than those in the Upper Sands," and by no means so abundant. "Sandstone concretions at *o*" in the diagram, fig. 3, of Frimley Ridge, in the Upper Sands, at p. 382.

1876. The Sarsens in the artificially picturesque rockery of the waterfall at the east end of Virginia Water are said to have been brought from the neighbouring heath; and those of the adjoining cavern or grotto from a cromlech there. Murray's "Handbook of Surrey," 2nd ed., p. 137.

1895. A Sarsen-stone footbridge over a streamlet at Frimley Green, Surrey, carries the footpath from the fields on one side of the stream that runs down a lane, to the path along the other side of the little stream, which runs beside the lane from Frimley Green, and across some fields to the border of Surrey and Hants near the Farnborough Station. The length of the bridge-stone is $4\frac{3}{4}$ or 5 feet; the width is about $2\frac{1}{4}$ feet equally all along; thickness

varies from 6 to 9 inches. The stones supporting the bridge and bank are laid regularly; they are all Sarsens, and others lie about irregularly. One lies near the fence just beyond the path on the further side of the bridge.—C. T. R. Jones.

1898. H. W. Monckton, Quart. Journ. Geol. Soc., vol. liv, pp. 185–193, treating of some gravels in the Bagshot district, notes that Sarsens occur at the base of these gravels, which are of the Glacial Period, and were probably of fluviatile origin. Sarsens with rootlet marks occur at Easthampstead. He doubts if any Sarsens occur in the Upper Bagshots, and supposes that probably most were derived from the Woolwich and Reading Sands. All the Sarsens must have been water-worn, or weather-worn before they were left in the gravel.

N.B.—At Camberley, in North Surrey, a Sarsen having a partial polish on one of its sides was noticed, and the polish is ascribed to the contact and rubbing of the dried stems of grasses and other plants (with siliceous tissue) moved by the wind.—T. R. J.

In Buckinghamshire Mr. Upfield Green, F.G.S., has observed both *pebbles* and prominences on *puddingstones*, smoothed and *polished*, on the sides of water holes, in the Brickearth near Great Missenden.

1900. Sarsen at Ballard's Farm, Croydon, a white saccharoidal sandstone with siliceous cement. Dr. G. J. Hinde has kindly given me the following notes on this large typical Sarsen near Croydon, which is visited by geological classes from London. Its dimensions are: length 4 ft. 10 ins.; width at one end 2 ft. 9 ins., at the other 2 feet; thickness at one end 1 ft. 8 ins., at the other 11 inches, and at another place 14 inches. It lies in a grass field on Ballard's Farm, on the south side of the bridle-path leading from Ballard's Lodge to the Addington Hills; and near to the outcrop of the sand-and-pebble beds of the Woolwich and Reading Series, of which indeed it is probably a concreted portion, like the similar blocks in the Caterham Valley.

(10) *Hampshire.*—1862. Captain H. Blundell (Staff College) noticed a large Sarsen in a ploughed field, about 4 miles from Winchester and 1 mile from Martyr Westley Rectory. It is 12 feet long, 10 broad, and 8 deep, "and bears a strong polish on a great part of one side," glaciated or polished by the friction of siliciferous stems of wheat. "The other side is hollowed out apparently by water."[1]

1898. Mr. A. E. Salter has seen a Sarsen in the gravel at Lee-on-the-Solent (Stubbington): Quart. Journ. Geol. Soc., vol. liv, p. 194.

(11) *Berkshire.*—1787. Daines Barrington made some remarks on the Greywethers in Berkshire (*Archæologia*, iii, p. 442).

1813. In W. Mavor's "Report on the Agriculture of Berkshire," 1813, at pp. 34, 35. The Sarsen Stones, or Greywethers as the country people call them, are irregularly scattered over the Berkshire and Wiltshire Downs. They are pretty numerous in a valley near Ashdown Park and on the road from thence to Lambourn.

[1] See also Lieut.-Col. Nicolls on "Sarsens," Southampton, 1866: Geol. Mag., Vol. III, pp. 296–298, Pl. XIII.

1854. T. Rupert Jones, in a lecture on the Geology of Newbury, treated of the occurrence of "the great blocks of Druidstone, Greywethers, or Sarsen-stones as the *only* remaining wreck of the Lower Tertiaries of this area"; and further broken up in the gravel of the vicinity.

1869. J. Adams, in a lecture on the Geology of Newbury (newspaper, December, 1869), referred to a traditional trace of an ancient cromlech near Hangmanstone, for people say that there was a cave made of large stones, but it was pulled to pieces by the farmer.

1869. The Sarsens of Berkshire now existing as relics of prehistoric monuments, especially in Wayland Smith's Cave, and the groups in Ashdown Park, are the subject of a paper by Mr. A. L. Lewis in the Trans. Internat. Congress of Prehistoric Archæol. at Norwich, 1869, pp. 37–46. See also Fergusson's "Rude Stone Monuments," 1872, pp. 121, etc.

1887. Mr. Walter Money, F.S.A., referring to Sarsen Stones in letters, notes that a writer in the *Gentleman's Magazine* for 1760 mentions that two Roman milliaria or milestones were to be seen near Aldworth; and this statement is confirmed by Hearne, Rowe Mores, and other authors. "These milliaria are now to be seen" (says the writer in the Gent. Mag.) "between Streteley and Alder, one of which lies a mile from Streteley, and by country people is supposed to be placed by the Giants (as they call them) in Alder [Aldworth] Church." He refers to the monumental effigies of the De la Beche family. A few years ago I investigated this subject for the late Mr. Thompson Watkin, of Liverpool, and found that one of these milliaria stood, not so many years ago, between Westridge Farm (two miles from Streatley) and Aldworth, in a bank, and that it was a large Sarsen Stone; and another I heard of as being seen in Kiddington Bottom, one mile west of Streatley. One of these, I learned, had been broken up for road-metal, and the other was said to have been taken away by a gentleman at Wallingford to be placed on his lawn.

Another statement is that many years ago the stone was taken from its original position by the side of the Roman *via* from Westridge to Streatley, and removed to a more convenient spot about a quarter of a mile distant, where probably it still remains. This stone, of gigantic size, was removed by the occupier of the farm at Westridge with a team of eight horses.

There is still a very large Sarsen Stone by the side of the Roman way from Newbury to Streatley, between Hampstead Norris and Aldworth, which was probably used as a milliarium. It is curious that in Brittany and other places on the Continent, as well as in England, where prehistoric stone structures are found, that there are stories of the imprints of giants' hands or feet, as the Friar's Heel at Stonehenge; and there is a story told at Aldworth at the present day, that one of these milliaria (that in Kiddington Bottom), between Aldworth and Streatley, had been thrown hither by one of the Aldworth giants, and that the print of the giant's

hand, made when he grasped the stone, may yet be distinctly seen. This corroborates the writer of the account in the Gent. Mag. of 1760.

Last year, on going over the Lambourn Downs, I was struck by seeing a huge Sarsen Stone, evidently roughly squared, about 5 feet out of the ground, by the side of the road. It has every appearance of a milestone of the last century; and on examining its face next to the road, I found that a flat face or panel had been cut as if to receive a plate or letters; but neither Mr. Barnes, who was with me, nor myself could trace any letters at all. There is little doubt that this is a Roman milestone, as this ancient road leads direct to Uffington Castle and White-horse Hill. This stone is called 'Hangman's Stone,' the same story being told about it as of the Hangmanstone near Chaddleworth, and about similar stones elsewhere in England. The stone (4′ 6″ long, 1′ wide, and 1′ 6″ high at each end) in Hangmanstone Lane is lying down, but the Lambourn stone is vertical as with ordinary milestones. It is not known as a boundary stone.

There are a great number of Sarsen Stones in the neighbourhood of Ashbury, at the western extremity of Berks, on the northern slope of the Downs, where they enter this county from Wiltshire; and it is singular that hamlets in this parish have the names of Id-stone, Od-stone, and King-stone Winslow, and just beyond is the parish of Bishop-stone (Wilts). Possibly the boundaries of these places were indicated by stones, presumably Sarsens, from their being so abundant at hand.

At Lambourn the boundary wall of the churchyard is built of Sarsens; some of them are 5 feet in height. Others are used as stepping-stones and for margins in the Bourn at Upper Lambourn.

Large Sarsens are still visible close to some old churches, as at Compton Beauchamp, East Shefford, and Merlstone, a tithing of Bucklebury; and they may be remains of material accumulated for pagan temples, at places now occupied by Christian churches.

"There was, and probably is, a row or avenue of Sarsen Stones in Whiteknights Park, Reading, leading to the Wilderness, which were said to have been supplied by the Kennet River Navigation, in early times, from the neighbourhood of Hungerford and Marlborough."—W. M.

1887. J. R. Hedges. There are many Sarsen Stones collected by Mr. Hedges for grotto-work at Wallingford Castle. Some are perforated by rootlet marks.

1887. Numerous Sarsens, small and of irregular shape (probably from the gravel in the neighbourhood), are arranged around a flower-bed at Theale Railway Station.—T. R. J.

Dr. Silas Palmer noted several large Sarsens observable at Hill Green, about 1 mile west of Leckhampstead Street, which is 6 miles nearly north of Winterbourne, 1 mile south-west of Peasemore, and about 2 miles north-east of Poughley in Welford Wood, and 2 miles north-east of the Hangmanstone in Hangmanstone Lane. These are cared for by Mr. Harold Peake, of Westbrook House,

Boxford; and Mr. Walter Money regards them as probably remnants of a chambered Long Room.

1887. In 1887 a buried or subterranean group of large Sarsens was discovered by Mr. Robert Walker at Middle Hole, a quarter of a mile north-west of Middle Farm,[1] about 2 miles north of Lambourn. Mr. F. J. Bennett (of the Geological Survey) gives the following description in his letters :—

A large leaning or nearly prostrate stone at the top of the group of stones had probably once been vertical, but had fallen down. The stones had been placed in a round pit-like hole, extending at least 10 feet north and south of the central stone (once upright).

A square excavation, more than 20 feet deep, was made, and some hundred Sarsens were taken out, weighing from a quarter to six hundredweight each; and there were left in the hole some stones of from 3 to 7 tons weight. In the hole the stones were in three irregular piles. The central heap rested on a very large flat stone; the others were at the two sides. The intervals were occupied by a stiff reddish clay with pottery, burnt and broken bones, wood-ashes, and burnt earth. There is a large flat stone lying in the valley not far off.

This north and south valley, or rather combe, in which this accumulation of Sarsens was found, has been cut down by denudation through the 'Chalk-rock' and the 'Melbourne Rock,' both recognizable in the side-slopes, and is floored with 'chalk-rubble.'

This does not appear to be one of the deep, well-like pits, lined with stones, tiles, clay, or wood, excavated for the purpose of marking boundaries in Roman times. It may have been sepulchral; for Thomas Wright, in his "Wanderings of an Antiquary, chiefly in the track of the Romans in Britain," 1894, pp. 176–178, describes in detail some large circular pits that have been filled with flints, and capped with broad Sarsens, on Aylesford Common; these, he thought, were probably sepulchral, and may have had a chamber opening out of the side at the bottom. (See ante, p. 115.)

1892. "A trail of large blocks of sarsenstone is prolonged by Hagbourne village to a line about 100 feet lower, on to the outcrop of the Upper Greensand. Other slopes along these Downs exhibit similar trails of sarsenstone." (Quart. Journ. Geol. Soc., xlviii, 1892, p. 313.)

At Newbury, Sarsens are frequent in the 'pitched' crossings of pavements at openings of yards; some are paved with squared setts. Worn, subangular, small Sarsens are plentiful in the gravel-pit south of the town.—T. R. J.

1896. W. Whitaker refers to the Sarsens at Streatley: Proc. Geol. Assoc., vol. xiv, p. 175.

(12) *Wiltshire.*—1767. Sir Joseph Banks, in his "Journal of an Excursion to Eastbury and Bristol, etc., in May and June, 1767" (reproduced with notes by S. G. Perceval in the Proceedings of

[1] Referred to at p. 149 of pt. i, 1886.

the Bristol Naturalists' Society, new series, vol. ix, pt. i, 1898), refers to the Sarsen Stones as follows: "Observed between Silbury and Marlborough the Stones called Grey weathers, which in one particular valley were scattered about in great numbers on the surface of the ground. The people in that neighbourhood were breaking great numbers of them, either to mend the roads or build houses, which gave me an opportunity of examining them and bringing away some pieces, which I found to be of a very hard and fine-grained Sand Stone. Whether it is found in beds in any part of this countrey I will not venture to say, but remember that some time ago, in seeing General Conway's place near Henley [Oxfordshire], I saw a large heap of such stones, some of them of an immense size; and, on asking where they were got from, was told that they were found scattered all over that countrey, lying on the stratum over the Chalk at different depths, and that those I saw had been got together, at a large expence, for some work to be done in the General's grounds—I think a bridge."

N.B.—This heap of large Sarsens must not be confused with the dolmen from Jersey reconstructed by General Conway in his grounds in the same locality, for the latter was necessarily only of granitic and such like rocks, native to Jersey. See also "The Channel Islands," by W. T. Austin & R. G. Latham, 1862; J. Fergusson's "Rude Stone Monuments," 1872, pp. 51, 52; and W. C. Lukis in the Trans. Internat. Congress Prehistoric Archæol. Norwich, 1869, p. 221.

1833. In the *Gentleman's Magazine*, vol. ciii, p. 542, is a notice of a paper read by Dr. G. T. Clark to the Bristol Philosophical Society, in which he alludes to the "Greyweathers" as being "scattered over the Chalky Downs of Wiltshire."

1863. W. H. Hudleston, in the Proc. Geol. Assoc., vol. vii, p. 138, gives a succinct account of the four kinds of stones that constitute the concentric rings of Stonehenge. The huge Sarsens composing the outer ring he described as consisting of a compact quartzose rock, derived from the Tertiary Sands. "These are, in fact, siliceous doggers or concretionary slabs of enormous size, which have hardened *in sitû* [in their original beds], and have resisted the atmospheric agencies of destruction. Several fragments were picked up of this material, which seemed to bear the marks of roots or something of the sort. It is by no means improbable, therefore, that the decomposition of vegetable matter, and consequent formation of *humus*, and the various organic acids which arise from its gradual alteration into carbonic acid, may have had something to do with the concretionary action. The influence of these organic acids on silica has been the subject of interesting investigations in America."

1871. Dr. Joseph Stevens, "On the Geology of North Hampshire," mentions the occurrence of a Greywether grindstone at St. Mary Bourne, Wilts. (Trans. Newbury District Field Club, vol. i, p. 86.)

1874. C. E. Davy, in a paper contributed to the Newbury District Field Club, "Letcombe Castle," 1874, p. 23, describes

a naturally-shaped, angular, pyramidal, water-worn fragment of Sarsen Stone as a prehistoric sacred stone.

1876. A critical account of the lithology of Stonehenge, by N. Story Maskelyne, was published in the Wilts Archæol. Nat. Hist. Soc. Mag., vol. xvii, pp. 149, etc.

1881. With regard to the carrying and raising large blocks of stone, the late Dr. V. Ball gave details and an illustrative plate of the method used among the hill-tribes of India. ("Economic Geology of India," 1881, p. 544, pl. viii; see also note in Pt. i, 1886, p. 125.)

1887. In a Reading newspaper (July 29, 1887) it was stated that at Wardour Castle "the picturesque grounds are ornamented with a pretty grotto and rockery, constructed from a number of curious-shaped stones, which formed a prehistoric circle at Tetbury," said to have been at or near Place Farm. This circular work is recorded as having had a large central stone, 12 feet high and 4 feet wide. (Britton's Topog. and Hist. Descript. Wilts, 1814; and W. H. Jones, Wilts Mag., vol. vii, 1863.)

1887. The Stones of Stonehenge were the subject of Mr. W. Whitaker's remarks in the Proc. Geol. Assoc., vol. ix, p. 530. "Dividing them roughly into two sets, the natives and the foreigners (the former, of course, being the bigger), the latter are mostly of igneous rocks, and must have been brought from a long distance; the largest of these, the altar stone, is a sandstone, but unlike any sandstone of the neighbourhood. The natives are all greywether-sandstone, or Sarsen stones which have been shown to be derived from some of the older Tertiary beds, here probably from the Bagshot Sand, which in these western parts comes nearer to the Chalk than further east. Their occurrence, therefore, points to a vast denudation of Tertiary beds, masses of clays and sands, that once spread far and wide over the now bare plateau of Chalk, having been slowly swept away, leaving behind only those hardened parts of the sands, that could withstand the denuding agents, as witnesses of the former extension of the beds."

1890. Treating of some constructions by a prehistoric (Neolithic) people in Wiltshire, Mr. F. J. Bennet alludes to the abundant local occurrence of Sarsens ("Sketch History of Marlborough in Neolithic Times," March, 1892, pp. 4, 8). He also indicates how Sarsens were used by the Neolithic folk in the boundary walls of the terraces of cultivatable ground in Wiltshire. That they were used afterwards in the building of houses, castles, churches, etc., is well known.

1894. Pebbles and flint-breccia in some Sarsens from Marlborough Forest in Professor Prestwich's collection, seen July, 1894.

1896. From Avebury a white saccharoidal sandstone, with siliceous cement, and containing an irregular, coarse, brush-like group of sub-parallel, tubular, and filamentous cavities, probably due to rootlets, stained with iron oxide.—F. Chapman.

1901. The block that fell this Winter at Stonehenge contains a layer of flints. It is No. 17 L (the lintel) of the map of Stonehenge by the Archæological Society of Wiltshire. — W. Cunnington, January 9, 1901.

(13) *Dorset.*—1842. J. Sydenham: "Baal Durotrigensis: A Dissertation on the Antient Colossal Figure at Cerne, Dorsetshire, etc.," 1842. In a footnote at p. 18, the Sarsens at Little Mayne (referred to at pp. 136 and 161 of my paper in the Wilts Mag., 1886) are recognized as relics of circles and parts of avenues.

1871. E. H. W. Dukin, "Megalithic Remains in South Dorset," in the Reliq. Quart. Archæol. Journ. and Review, 1871, pp. 12–15 (separate copy), refers to the stones at Little Mayne. Mr. C. Warne also (1872) notices those old stones in his "Antient Dorset," quoting Sydenham's "Baal Durotrigensis."

1871. Poxwell, Pogswell, or Pockswell, is a village about 5 miles north-east of Weymouth, on the Wareham Road, and at about a quarter of a mile south-east of the church is a small circle of rough Sarsens, brown in colour, with much quartz-crystals in cavities. The stones are much split on the surfaces in squarish irregular segments, with something like gaping fissures. (Dukin, 1871, and T. R. J. 1887.)

Amongst the Sarsens of Dorset, many of them now relics of ancient structures, but originally scattered over the surface of the country, there are evidently many conglomerates. The grooved, or probably holed and broken, stone at Tennant Hill Circle, consists of a "hard puddingstone or conglomerate" (Dukin, 1871, p. 12). The circle at Winterbourne Abbas is described (ibid., pp. 4 and 5), partly after Stukeley; and it is stated there are "ten stones of a very hard sort, full of flints; the tallest to west eight feet high, the north seven feet broad, six feet high" (op. cit., p. 5). The usual ridiculous belief in devil handiwork still exists in Dorset and Cornwall (op. cit., p. 9).

1887. At Fordington Green, Dorchester, at the east end, at the corner of a house bearing the Ordnance Survey Bench-mark, is a Sarsen; the top is three-faced (4 feet where widest, and 2 ft. 7 ins. high), the sides rounded. This stone some people removed not very long ago, but others had it brought back and replaced.—T. R. J.

(14) *Somerset.*—1888. Many Sarsens in the country around Taunton along the roads and lanes, and in villages at corners, farm-gates, etc.

In the Castle grounds at Taunton, in the gardens of the Archæological Society, there is a Sarsen that has been set up as a memorial stone to one of their officers. It is somewhat triangular in outline, 4 ft. 6 ins. high, and 6 ft. 2 ins. at its widest part near the base. Smoothly rounded and irregularly pitted on one face, and flat (apparently split) on the other. It bears a tablet with inscription to the memory of W. A. Jones, who was Secretary to the Society for 20 years. It also refers to the donation for buying the grounds for the Society, made by the friends of Mr. W. A. Jones.—W. Bidgood.

1888. Numerous Sarsens are passed on the road from Taunton for about 10 miles to Staple Fitzpaine, where in a hedge-bank are several such stones, one of which, 5 feet long, and 4 feet high or thick, above ground, with its surface rounded and water-worn, is locally known as the 'Devil's Stone'; for, having knowledge of the

intended building of a church there, he gathered a few rocks as he came thither, but, getting tired, slept on the bank, until he awoke in the morning, and to his astonishment saw the fine tower of the church already up and finished. In his hurry to get up, his satchel broke, the stones fell out, and one in particular remains there now! This is the most western of the Sarsens that I know of.—T. R. J.

The microscopic structure of a piece of one of the blocks at or near Staple Fitzpaine, which had the appearance of a Sarsen, is thus described by Mr. Fred. Chapman, A.L.S. :—"This rock is largely composed of angular and subangular chips of quartz and chert, cemented by a kind of paste of fine quartz sand and limonite. The included fragments are very variable in size, the angular predominating over the subangular. A fair proportion of the fragments are of secondary quartz; some clear, others with strings of gas-cavities. There are a few chips of a somewhat brecciated rock, not unlike a decomposed rhyolite in character. There is at least one fragment of flint in the section examined. The chert fragments, possibly of Cenomanian age, contain a few examples of *Globigerina cretacea*. One of the larger pieces included in this Sarsen (?) is a chert, crowded with *Radiolaria*, in a generally good state of preservation, some of the organisms bearing long spines beset with smaller spines. Dr. G. J. Hinde, who has been good enough to examine the slide, thinks that there is not enough evidence for the identification of genera, but that the chert is most probably of Palæozoic age."

1888. In the Museum of the Bath Institute I saw a somewhat water-worn block of light-coloured saccharoidal sandstone, looking very much like a Sarsen; chips of this stone show an ochreous tint and siliceous cement. The Rev. H. H. Winwood, F.G.S., Honorary Curator of the Museum, informs me that it came from the Victoria Gravel-pit, on the right of the Somerset and Dorset Railway, where the road crosses the line at South Hill. It measures 33 inches in length, 16 inches where it is broadest, and 4 to 7 inches in thickness. With other similar blocks it lay at the base of the gravel on the blue Lias clay. At first he was inclined to regard it as having been derived from the Millstone Grit of the Wick and Bristol district; but he has since seen sarsenic pebbles and blocks in the Gravel, and he noticed a large Sarsen at the Westbury Ironworks. Near Downhead, in the Mendips, he has observed numerous siliceous blocks having the appearance of Sarsens; but others just like them, lying on the north slope of the Mendips at Ashwick, contain Liassic fossils. Great caution, therefore, is necessary in determining these somewhat similar siliceous blocks of Palæozoic, Secondary, and Tertiary age respectively.—H. H. W.

(15) *Devon.*—In 1822 Dr. Buckland described the large, isolated, siliceous blocks, scattered about on the hills near Sidmouth, as being much like the Hertfordshire Puddingstone, but having the included flint "mostly angular" and not rounded. In 1826 he referred to these in Devon, and others in Dorset and elsewhere, as being the same as the recognized Greywethers. (Trans. Geol. Soc., ser. II, vol. ii, pp. 126, 127.)

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VI.—THE AGE OF THE EARTH AND THE SODIUM OF THE SEA.[1]

By ARTHUR R. HUNT, M.A., F.G.S.

PROFESSOR J. JOLY, in his interesting paper estimating the geological age of the earth from the amount of sodium contained in the sea,[1] mentions in an appendix seven possible errors which may render his estimate a minimum, and seven others which may render it a maximum. Neither among the former errors

[1] Trans. Roy. Dublin Soc., vol. vii (1899), p. 23.

guarded against in the appendix, nor in the body of the paper, does there appear any reference to the possibility of sea-water being absorbed by the surface rocks of the globe, either by capillary attraction, as maintained by Daubrée, or by means of fissures, as contended by De la Beche.

The possibility—nay, the probability—of sea-water obtaining access to the deep-seated and heated regions of the globe was admitted by Lyell, De la Beche, and Daubrée, and by other eminent geologists; and although to a large extent neglected at the present time, the arguments in favour of the hypothesis seem worth considering.

My own attention was attracted to the subject as follows:—From 1879 to 1889 inclusive, I wrote seven papers on the detached blocks which lie strewn on the bottom of the English Channel. The primary object of the enquiry was to ascertain whether the blocks represented a prolongation of the Dartmoor granite, as commonly supposed, and whether they were in any way related to the metamorphic rocks of the neighbouring headlands of the Start, the Prawle, and the Bolt.

I commenced the investigation in the full expectation that the connection with Dartmoor would be proved at once.

I secured thirty-four crystalline rocks from the Channel, and a large collection from Dartmoor. Not a single speck of tourmaline or crystal of chloride of sodium did I detect in the twenty granites and gneisses from the Channel; while not a single slice from Dartmoor failed to indicate chlorides, and very few of the Dartmoor rocks from which they were cut (if any) were without tourmaline. The fluid inclusions in the Channel rocks were of a different type from those in the Dartmoor rocks. The two series of rocks seemed absolutely distinct.

This most unexpected result greatly excited my curiosity, and I sought to find some explanation. Finally, in 1889, I hazarded the suggestion that sea-water had gained access to the Dartmoor granite in Carboniferous times; and in 1892, after an examination of the South Devon schists, I, for entirely different reasons, threw out the suggestion that they also had been influenced by the presence of sea-water during their metamorphosis.

These suggestions were not only almost universally rejected by geologists, but they caused considerable umbrage, so I discontinued the enquiry, and put away my microscope.

However, before bringing my own work to a conclusion, I examined the older authorities, and found that both Lyell and De la Beche maintained the hypothesis that sea-water reached the heated rocks, and that subsequently the late Mr. J. A. Phillips and M. Daubrée were of the same opinion; and, strange to say, they all had different reasons for their belief. My own conclusions were also based on entirely independent evidence; and, indeed, so far as appears from the records, all the observers thought out the problem independently from different points of view. Lyell relied on the steam emitted by volcanoes, De la Beche appealed to his mineral

veins, Phillips pointed to hot salt-springs transforming the rocks at considerable though accessible depths, Daubrée relied on experiment, while I have been impressed by the characteristics of the vein rocks of Dartmoor with their abundant sodium (as chloride and silicate), and with the chlorite, amphibole, and albite of the green schists.

The conclusions of De la Beche seem the most noteworthy, seeing that he was necessarily ignorant of the fact that the vein rocks of Devon and Cornwall are charged with salt and brine. In 1839 that acute observer wrote—"There is, therefore, nothing unreasonable in supposing that a large proportion of the Cornish and Devon fissures, now wholly or in part filled up, were opened either beneath the sea or in such situations that portions of them were so placed that it entered freely into them" (Report on Geology of Cornwall and Devon, p. 378). Subsequently De la Beche cites an instance of water filtrating through hard basalt, filling its internal cavities with liquid, and setting up crystallization of 'mesotype' (loc. cit., p. 392). In 1851 De la Beche touches on the chemical combinations of the chlorides in the fissures (Geol. Observer, p. 770).

In January, 1873, the late Mr. J. A. Phillips read a most interesting paper to the Royal Society, which was subsequently communicated to the *Philosophical Magazine*. In it the author discusses the composition and origin of the waters of a salt-spring at Huel Seton mine, with a chemical and microscopical examination of certain rocks in its vicinity. The water is shown to be derived from the sea, and to enter into chemical combination with the minerals of the rocks through which it passes, producing brown hornblende, pale-green actinolite, and chlorite. Another salt-spring, in the now abandoned Huel Clifford mine, was 1,320 feet below the sea, and issued at a temperature of 125° F. As Mr. Phillips does not refer to De la Beche, he seems to have overlooked De la Beche's views, just as I unfortunately overlooked at first both De la Beche and Phillips. The result, however, is that all three identical conclusions were arrived at independently, and all on different grounds. Had De la Beche lived to learn that the quartz in his fissures actually contained brine and crystals of salt, and that the felspar of his veins, instead of being the orthoclase of the main mass, was triclinic, and more or less a soda-felspar, he would have realized with what unerring sagacity he had hit his mark.

In 1880 Daubrée published his invaluable "Géologie Expérimentale," of which work the third chapter is headed—"Expériences sur la possibilité d'une enfiltration capillaire au travers des matières poreuses."

Daubrée shows experimentally that bottom heat greatly accelerates the passage of water through rocks in the face of a strong counter-pressure of steam. He incidentally admits that such water may be salt water, and that it would be capable of producing great mechanical and chemical effects. But this is incidental; his object is to explain the origin of volcanic steam, not to follow up the new combinations of the sodium which the steam leaves behind in the bowels of the earth.

Lord Kelvin [1] and Professor Joly agree in assuming that because melted basalt is lighter than consolidated basalt the chilled surface of a lava ocean would sink: Lord Kelvin further assumes that all minerals crystallizing out of a melted basalt would also sink: I would, however, venture to submit that the gases imprisoned in the chilled surface layers would buoy them up, and that a good many minerals, lighter than the magma, on rising to the surface would form a scum or slag which, by blanketing the glowing lava, would thereby check radiation. I have no especial interest in the controversy as to the age of the Earth, and go no further than to suggest that these points should be allowed their due weight in the argument.

The application of the above sea-water hypothesis to the cases of Dartmoor and the schists is a somewhat intricate question, and not worth discussing so long as the main principle is rejected.

VII.—Notes on Literature bearing upon the Geology of the Malay Peninsula; with an account of a Neolithic Implement from that country.

By R. Bullen Newton, F.G.S., of the British Museum (Natural History).

In view of the interest lately shown by geologists and others engaged in the Malay Peninsula through Mr. H. F. Bellamy's discovery of Triassic Lamellibranchs in that area, a brief account of the principal works on the geology of that portion of South-Eastern Asia may prove of service. More particular reference will be made to the sedimentary rocks, purely mineral papers being excluded from consideration.

One of the earliest records on this subject is by William Jack,[2] who in 1822 observed a red sandstone at Singapore which he regarded as "the chief secondary rock" of the district. He further mentioned that the Island of Penang was entirely of granitic structure. Somewhat later the following remarks were made by J. Crawford:[3] "At Singapore a secondary formation is discoverable, and varieties of sandstone and shale form the principal rocks, together with conglomerate, argillaceous sandstone and gray limestone."

In 1847 Colonel James Low,[4] speaking of the same rock at Singapore, stated that "the sandstone lies immediately under the Oolitic beds, and would be therefore New Red Sandstone." The discovery of a bituminous coal on the southern coasts of the Island of Junk-Ceylon off the Malay Peninsula was reported by J. R. Logan [5]

[1] Trans. Victoria Inst., vol. xxxi, p. 24.

[2] W. Jack, "Notice respecting the Rocks of the Islands of Penang and Singapore": Trans. Geol. Soc. London, ser. II, vol. i, pt. 1 (1822), p. 165.

[3] J. Crawford, "Geological Observations made on a Voyage from Bengal to Siam and Cochin China": Trans. Geol. Soc. London, ser. II, vol. i, pt. 2 (1824), p. 406.

[4] Col. Jas. Low, "Notes on the Geological Features of Singapore": Journ. Indian Archipelago, vol. i (1847), p. 83.

[5] J. R. Logan, "Notice of the Discovery of Coal on one of the Islands on the Coast of the Malay Peninsula": Quart. Journ. Geol. Soc., vol. iv (1848), pp. 1, 2. "On the Local and Relative Geology of Singapore, etc.": Journ. Asiatic Soc. Bengal, vol. xvi (1847), pp. 519–557, 667–684. "Sketch of the Physical

during the following year, but no geological age was assigned to the material. This author likewise contributed a number of papers between 1847 and 1851 on the geology of the Malay region, dealing more particularly with that division of it which embraces Singapore and the adjacent islands. He observed that limestone, sandstone, and clays are the predominating stratified rocks along the western coast from Junk-Ceylon to Penang; and that argillo-micaceous and argillaceous schists, associated with sandstones and common clays and shales of various colours, occur between Southern Selangor and Johore.

During 1879 Mr. Patrick Doyle[1] referred to the granitic rock of the Malay Peninsula as being "overlain generally by sandstone, and frequently also by laterite or cellular ironstone, and to the north by limestone."

In 1882 Mr. D. D. Daly[2] mentioned that "the alluvial tin deposits permeate the whole length of the Malayan Peninsula"; and among other items of geological interest, the occurrence of limestone caves at Batu in Selangor was pointed out. The following year Mr. A. H. Keane[3] remarked that "as far as has been ascertained, the main geological formations [of the Malay Peninsula] would appear to be Lower Devonian sandstones and unfossilized clay-slates, with a basis of stanniferous granite everywhere cropping out. Although no trace has been found of recent volcanic action, there are several isolated and unstratified limestone masses from 500 to 2,000 feet high, of a highly crystallised character, with no fossils of any kind." In the same year M. J.-E. de la Croix[4] alluded to the presence of three groups of rocks in the Perak district of the Malay Peninsula: (*a*) the eruptive series, which constitute the mountain masses; (*b*) the sedimentary beds, which occur at intervals in detached fragments; (*c*) the alluvium formation, which completely covers the plains. The sedimentary strata are represented by sandstone and limestone, both of which are unfossiliferous and consequently of unknown age, although stated to be anterior to the granites, which are eruptive and metamorphosed.

In 1884 the late Rev. J. E. Tenison-Woods[5] referred to a "Palæozoic

Geography and Geology of the Malay Peninsula": Journ. Indian Archipelago, vol. ii (1848), pp. 83–138. "Notices of the Geology of the East Coast of Johore": Journ. Indian Archipelago, vol. ii (1848), p. 625. "The Rocks of Pulo Ubin": Verhandel. Bataviaasch Genootsch. Kunst. Wetenschap., vol. xxii (1849) [read 1847], pp. 3–43. "Five Days in Naning": Journ. Indian Archipelago, vol. iii (1849), p. 282. "Notices of the Geology of the Straits of Singapore": Quart. Journ. Geol. Soc., vol. vii (1851), pp. 310–344, pl. xviii (=geological map).

[1] Patrick Doyle, "On some Tin-deposits of the Malayan Peninsula": Quart. Journ. Geol. Soc., vol. xxxv (1879), p. 229.

[2] D. D. Daly, "Surveys and Explorations in the Native States of the Malay Peninsula": Proc. Roy. Geogr. Soc., N.S., vol. iv (1882), pp. 393–412.

[3] A. H. Keane: "Malay Peninsula," an article in the *Encyclopædia Britannica*, 9th ed. (1883), vol. xv, p. 321.

[4] J.-E. de la Croix, "Le Royaume de Perak": Bull. Soc. Geogr. Paris, ser. VII, vol. iv (1883), pp. 342–348, with a plate containing geological map and sections.

[5] J. E. Tenison-Woods, "Geology of the Malaysan Peninsula": *Nature*, vol. xxx (1884), p. 76. "Physical Geography of the Malaysan Peninsula": *Nature*, vol. xxxi (1884), p. 152. "The Geology of Malaysia, Southern China, etc.": *Nature*, vol. xxxiii (1886), p. 231.

sandstone clay-slate" in the Malay Peninsula which he thought had not been previously noticed; and subsequently the same writer described the country as an elevated granitic axis with Palæozoic schists and slates at its base, mentioning also the occurrence of detached masses of weathered limestone without fossils.

In speaking of the gold deposits of Pahang, Mr. H. M. Becher[1] stated in 1893 that "the gold-quartz formation of Pahang traverses an extensive series of sedimentary rocks. . . . . These rocks, probably of Palæozoic age, are for the most part thinly bedded slates with some sandstones, and fewer dark-coloured, impure limestone beds." Alluvial beds of modern origin were also referred to.

Dr. Koto[2] followed in 1899 with a brief allusion to this area, and, quoting from a previous author, mentioned the occurrence of "granites, old-looking sandstones, and slates," extending down to Singapore.

Finally, the present writer[3] described and figured the Lamellibranch remains discovered by Mr. H. F. Bellamy in a sandstone obtained on the Pahang Trunk Road near the Lipis River. A study of this fauna proved it to be of Upper Triassic age (= Rhætic), the matrix being termed a 'Myophorian Sandstone,' on account of the prevalence of the genus *Myophoria*. These shells, the first recorded fossils from the Malay Peninsula, were determined as under:—

Chlamys Valoniensis, Leymerie, sp.
Pteria Pahangensis, R. B. Newton.
Gervillia inflata, Schafhäutl.
Pteroperna Malayensis, R. B. Newton.
Actinodesma Bellamyi, R. B. Newton.
Pleurophorus elongatus, ? Moore.
Mytilus allied to *M. minutus*, Goldfuss.
Myophoria ornata, Münster.
Myophoria inæquicostata, Klipstein.
Myophoria Malayensis, R. B. Newton.
Myophoria, sp.

Among unpublished observations it may be of interest to reproduce, from a letter of recent date, an account of the geology of the River Tui District, situated in the Pahang division of the Malay Peninsula, written by Mr. R. M. W. Swan, F.G.S., who is carrying out mining operations in that area. The Tui is described as a small branch of the River Jelai, which joins the Lipis River at Kwala Lipis, from which place it is about ten miles due north. Thanks are due to Mr. Swan's brother (Mr. Archibald A. Swan) for permission to include this new matter in the present paper.

"In order to explain the geology of the place where we are working it is necessary to say a few words on the geology of this part of Pahang. The common rock of the country is a clay slate, or perhaps more properly shale, for the cleavage of the rock coincides with the original bedding planes, although these have been

[1] H. M. Becher, "The Gold-quartz Deposits of Pahang (Malay Peninsula)": Quart. Journ. Geol. Soc., vol. xlix (1893), p. 84.

[2] Dr. B. Koto, "On the Geologic Structure of the Malayan Archipelago": Journ. Coll. Sci. Univ. Tōkyō, Japan, vol. xi, pt. 2 (1899), p. 85.

[3] R. B. Newton, "On Marine Triassic Lamellibranchs discovered in the Malay Peninsula": Proc. Malac. Soc. London, vol. iv (1900), pp. 130–135, pl. xii.

accentuated by pressure at right angles to them. These slates rest on a basin in granite, and by a movement of this rock they have been highly tilted, so that the average dip is about 80°. The underlie here is westward, while nearer the dividing range of the Peninsula it is eastward. The dip changes along a line about $6\frac{1}{2}$ miles westward from here. The strike of the slates is extremely regular, and is parallel to the main dividing range, or 8° to $8\frac{1}{2}$° west of the magnetic north. The mass of slate rock is penetrated by numerous intrusions, which consist generally of granite or greenstones. All the known mineral deposits of any value in Pahang are either included in these intersecting rocks, or occur in close proximity to them. The intrusions generally take the form of large lenticular masses, which are often some miles in width. The main axis of these masses is always parallel to the strike of the slates, and the intrusive rocks sometimes show a cleavage produced by side pressure, parallel to the cleavage of the slates.

"These intrusions are highly developed in some parts of the country. There is a granite intrusion $1\frac{1}{2}$ miles to the westward of the Tui. This is succeeded to the eastward by a belt of slate about a mile in width, and then we have a belt of intrusive rock about a mile in width, and it is on this that the Tui flows.

"Overlying all these rocks, and resting on their upturned edges, is a deposit of crystalline limestone, which was originally very extensive, and of great thickness. It certainly has been some thousand feet thick, and there is some evidence which seems to show that it has overlain even the tops of the main dividing range. But only a few isolated patches of this limestone now remain, the rest having been eaten away by the comparatively rapid action of denudation. The limestone in which we are mining is a small patch which remains in the bottom of an ancient valley. Tradition indicates that the Chinese have exported much gold from this part of Pahang, and there is good reason to believe that most of this gold has been derived from the limestone, and has been left on the surface when that rock has been dissolved away. I feel fairly certain that such has been the origin of practically all the gold exported from the Tui valley.

"The clay deposit was composed of fine yellow clay, which contained some spherical nodules of iron oxide, and rarely some fragments of quartz. The gold was not distributed through the mass, but occurred in occasional streaks or veins, which could not be distinguished by the eye. . . . .

"This clay deposit, which covers the whole of the limestone in the valley to a depth of about twenty feet, is the product of decomposition of the greenstone which forms the sides of the valley, and the peroxide of iron nodules which accompany it had their source in the hornblende of that rock."

Remarks.—From the foregoing notices it would appear that the Malay Peninsula is largely composed of plutonic rocks more or less covered by sedimentary strata, of which sandstone, slates, and

limestone form a very considerable part. The fossils discovered by Mr. Bellamy have enabled the writer to refer the sandstone to a Triassic age, but the horizon of the limestone and slate deposits still remains doubtful. Quite recently, some samples of the limestone were submitted to the writer for microscopical examination by Mr. Archibald A. Swan, which his brother, Mr. R. M. W. Swan, F.G.S., had collected and sent home from the River Tui District; but they, unfortunately, exhibit no organic structures, and are therefore practically useless for determining their period of deposition. This limestone[1] is of blackish colour, very much fissured with calcite and quartz, and possessing slickensided surfaces; a microscopical section with the aid of polarized light exhibiting the brilliant coloration of its partial siliceous structure. In the neighbourhood of the quartz veins, gold, blende, stibnite, and galena are more or less observable. It occurs in a basin-shaped area situated on the upturned edges of contorted slates of unknown age, which themselves rest on a granite base. It is more than probable that this limestone may crop out elsewhere in the neighbourhood of a less crystalline character, and with palæontological features; but until such a discovery takes place it is premature to assume its definite geological age. Should it ultimately prove to be of Carboniferous age, then it would probably form a continuation of that limestone found in Sumatra (Padang) which has yielded to Brady[2] and other authors the foraminiferal genus of *Schwagerina* (= *Fusulina* of Brady).

In referring again to the sandstone rocks of the Malay Peninsula it may be mentioned that they represent part of the great Triassic development which is such an important feature in the geological structure of Eastern Asia, and which extends through European countries to Northern Africa, thence to Asia Minor, the Himalayas, and to portions of the Chinese Empire, Japan, and Siberia. It is found also in the East Indian Archipelago, especially Sumatra, Rotti, and Timor; and, moreover, it is present in New Caledonia and New Zealand.[3] In all these regions the occurrence of Triassic rocks has been accurately demonstrated by the palæontological investigations of Stoliczka, Griesbach, Volz, Koken, Eugène Deslongchamps, Rothpletz, Naumann, Zittel, Loczy, and others.

Neolithic Implement.—Whilst writing on the geology of the Malay Peninsula, it may not be out of place to allude to a Neolithic implement from that country which was presented to the Geological Department of the British Museum by Mr. W. Leonard Braddon, M.R.C.S., during the latter part of 1896. Two examples exist of

[1] Specimens of the limestone have been presented to the Mineral Department of the British Museum (Nat. Hist.) by Mr. A. A. Swan, a few examples being retained for reference in the Geological Department.

[2] H. B. Brady, "On some Fossil Foraminifera from the West Coast District, Sumatra": Geol. Mag., 1875, p. 537, pl. xiii, fig. 6.

[3] See Lapparent's map illustrating the Triassic distribution, "Traité de Géologie," 4th ed. (1900), p. 1042.

this implement celt, both of which were found in a disused mine at Tras, Pahang, having probably been utilized for mining purposes in connection with the production of tin, which largely abounds in this region.

They are similar in shape, being long, narrow, and of rectangular section, with an inclination to a convex upper surface caused by a gentle declivity at each end; widening very gradually to the cutting end, which thins off into a moderately sharp, chisel-shaped edge. The opposite and rather narrower extremity is more or less of a wedge pattern, and somewhat tapering thereby, suggestive of the implement having been fixed to a wooden handle to carry out the functions of a 'pick' or similar instrument, an idea further strengthened by the fact that near the same end are some coarse scoring marks which run in various directions, resembling furrows, most probably produced by the process of shafting with a strong vegetable fibre. Similar scored lines are observable on some Malay implements in the British Museum Collection at Bloomsbury.

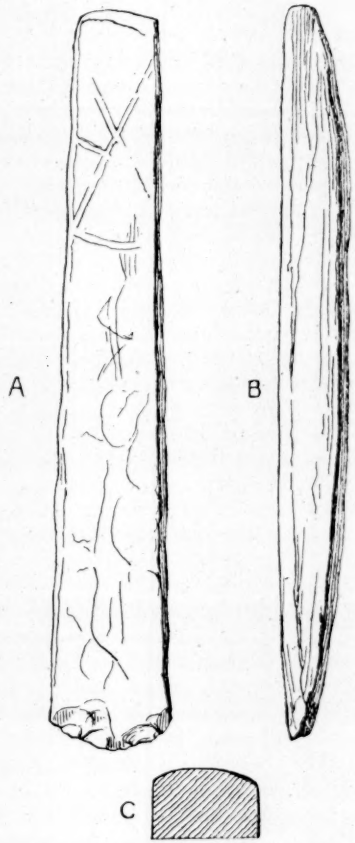
The rock composing these implements outwardly resembles a material of igneous origin, but Mr. G. T. Prior, M.A., of the Mineral Department, British Museum, assures the writer that such is not the case. It is more probably a mudstone or an indurated slate, which under the microscope is seen to exhibit a fragmentary structure with occasional crystals of felspar. Nor can any organisms be traced in it such as the minuter forms of life, Radiolarians or Foraminifera. It is a rock of extreme hardness, very closely grained, and of a densely dull, black colour where fractured, and having a clear metallic ring when struck.

Externally, the implements are partially coated with a thin layer of light colour, which is easily powdered away by scraping, and which has possibly been produced by entombment in an alluvial deposit; in other places smooth, polished surfaces are seen, evidently the result of former handling and usage.

According to Sir John Evans, F.R.S., similar chisel-like implements, but of various rock structures, occur very rarely in Britain and Ireland, more commonly in Denmark and North America, and sometimes in Siam and the Malay Peninsula. (Vide "The Ancient Stone Implements, Weapons, and Ornaments of Great Britain," 2nd ed., 1897, p. 121.)

Beyond the occurrence of these implements nothing further appears to be known of the Neolithic period as affecting the Malay Peninsula. The cave explorations undertaken by Mr. H. N. Ridley yielded no other relics connected with man's history at that time, for we read in his report: "It was to be hoped that remains throwing light on the Stone-age men of the Malay Peninsula might have been found in the caves, but as yet nothing has been found anywhere in the Peninsula except the axes themselves" ("Caves in the Malay Peninsula": Rep. Brit. Assoc. Bristol, 1898, pp. 571–582, 1899). Although the literature on this subject is apparently very restricted, the writer would gladly welcome any additional references known to students of Ethnography.

Dimensions of best example: Length, 12 inches; width of chisel end, $1\frac{3}{4}$ inches; width of narrower end, $1\frac{1}{2}$ inches; central depth, $\frac{9}{10}$ inches.



Illustrations of a Neolithic Implement obtained by Mr. W. L. Braddon from a disused mine at Tras, Pahang, Malay Peninsula. Figures drawn one-third natural size.

A.—Lower surface, showing scored markings.
B.—Side view showing slight convexity of upper surface.
C.—Rectangular section of the less perfect specimen, which measures 1 inch in central depth.

VIII.—Origin of Coal.

By J. R. Dakyns, Esq.

IN his interesting paper on "The Origin of Coal," published in the Geological Magazine for January, 1901, p. 29, Mr. Strahan says: "the Limestone Series generally consists of repetitions of small groups of strata, each group being composed of sandstone, followed by shale, shale followed by limestone." It is not stated whether this is intended to be an upward or downward succession; but if the former is meant, as it seems to be, the sequence is very different from that which exists in many parts of the country. Amongst the Yoredale Rocks *proper*—by which I mean the beds in the valley of the Yore and in such parts of the neighbourhood as contain rocks of a similar type—the usual upward succession is sandstone followed by limestone overlaid by shale. That is to say, the limestones very often have basement sandstones, and are nearly always immediately overlaid by shale. There are some cases in which limestone is overlaid by sandstone, but these are quite exceptional.

As it seems from recent discussions at Bradford to be not generally known, I may as well state that the Yoredale type of beds does not exist south of the Craven fault; as a matter of fact, it dies out between Kettlewell and Grassington.

Mr. Strahan also says that "underclays do not resemble soils, inasmuch as they are perfectly homogeneous." Now on many parts of the Millstone Grit moorlands in Yorkshire, the hill peat rests on yellowish clay, formed by the decomposition of the underlying rocks. This clay (which may be called the peat underclay) looks so like a Coal-measure underclay, that one is led to think that both had a similar origin, however different may have been the circumstances. Of course, when an underclay occurs in the midst of a coal, or on top of coal, it cannot have been formed by decomposition of underlying rock. In such cases, which are exceptional, it must have been drifted somewhat. But even if all underclays were drifted, that would not prevent their having been the seats on which coal-forming plants grew, and the striking resemblance of peat underclays to coal underclays makes me think that the latter clays were the seats on which the coal plants grew.

REVIEWS.

I.—Geology of the South Wales Coalfield. Part II: The Country around Abergavenny. By Aubrey Strahan, M.A., F.G.S., and Walcot Gibson, F.G.S.; with Notes by J. R. Dakyns, M.A., and Prof. W. W. Watts, M.A., F.G.S. Memoirs of the Geological Survey. 8vo; pp. 103. (London: printed for H.M. Stationery Office, 1900. Price 2*s.*)

THIS memoir is written in explanation of the New Series map sheet 232. It includes a brief account of the Silurian rocks of part of the Usk inlier, and a fuller account of the Old Red

Sandstone which stands out boldly in the 'Sugar Loaf.' The result of the resurvey of these rocks has been to show that there is a well-defined plane up to which a Ludlow fauna and a Ludlow type of sediment extend, while above it the Old Red type with Lower Old Red fossils only have been recognized. Locally there is no gradation from Silurian to Old Red Sandstone. On the other hand, no break has been found in the Old Red Sandstone, although the fossils show that both Lower and Upper divisions are present. It is remarked that the formation is "not necessarily purely lacustrine or fluviatile."

From the Old Red Sandstone upwards there is perfect conformity with the Carboniferous strata. The Carboniferous Limestone with its base of Lower Limestone shales is a variable group, 500 feet thick in the western part of the district and about 100 feet in the eastern part. Professor Watts describes some of the oolitic bands of limestone, and also an interesting mass of dolomite. Mr. Strahan found that the white oolitic limestone in one area underwent a considerable change in mineral character, and this proved to take place both along the outcrop and vertically. Analyses showed that the change was due to the replacement of a portion of the carbonate of lime (about 30 per cent.) by carbonate of magnesia, and to a recrystallization of the whole rock, whereby all organic structure, even the oolitic grains, were obliterated, and the rock became a true crystalline dolomite. Reference is made to the probable connection between the dolomitization and faults which would have afforded means for the circulation of mineral waters. Full accounts are given of the Millstone Grit and Coal-measures, including the iron-ores, which are now but little worked. The coals are more extensively worked now than formerly, and are being followed southwards under the deeper parts of the basin.

In the account of the Glacial Drifts a description is given by Mr. Gibson of a transported mass of Millstone Grit which forms a small hill upwards of 200 yards in length, and was found to be based on stiff glacial till. "The hill, therefore, is merely a huge boulder, bearing witness to the great carrying power of the ice."

II.—The Geological Survey of Canada.

1.—Report on the Geology and Natural Resources of the Country traversed by the Yellow Head Pass Route from Edmonton to Tête Jaune Cache, comprising Portions of Alberta and British Columbia. By James McEvoy, B.A.Sc. Geological Survey of Canada, Annual Report, Vol. XI, Part D. 8vo; pp. 1D–44D, with map. (Ottawa: S. E. Dawson, 1900.)

THIS report is descriptive of an exploration which extended from Edmonton westward through the Yellow Head Pass in the Rocky Mountains, down the Fraser River to Tête Jaune Cache, and thence to the head-waters of Canoe River, a tributary of the Columbia. A map on a scale of 8 miles to 1 inch accompanies the report; it embraces the whole of the area traversed, and extends in

latitude from 52° 36′ to 53° 45′ N. and in longitude from 113° 20′ to 119° 35′ W. There are also views of the mountainous scenery characteristic of parts of the Athabasca and Fraser Rivers.

The writer enumerates the various expeditions that have penetrated this region, including those of the Hector-Palliser expedition (1859), and the better known journey of Lord Milton and Dr. Cheadle (1863, "The North-West Passage by Land"), as well as the later one undertaken by Dr. A. R. C. Selwyn in 1871.

The formations met with in the district explored were as follows :—

Tertiary	...	Paskapoo Beds.	Laramie.
Cretaceous	...	Edmonton Beds.	Laramie.
		Pierre and Fox Hill.	
Devono-Carboniferous.			
Cambrian	...	Castle Mountain Group.	
		Bow River Series.	
Archæan	...	Shuswap Series.	

The *Upper Laramie* (Paskapoo Beds) were identified on the west bank of the Pembina River, and consisted of about 50 feet or more of thick beds of yellowish-grey sandstones. The Lower Laramie, as distinguished by its fossils, was met with on Sandstone Creek, a small tributary of the Athabasca River, where a section showed that the rocks consisted of clayey sandstones, associated with coarser sandstones, carbonaceous shales, and seams of coal.

Cretaceous rocks were represented by rather coarse green sandstone, interbedded near the mountains with greenish conglomerate, with (further eastward) black argillaceous shale, including thin seams of lignite. These rocks were seen in ascending Prairie Creek, a tributary of the Athabasca, the mouth of which is about ten miles from that of Sandstone Creek.

Owing apparently to the imperfect evidence afforded by the fossils the succeeding group of rocks bears the dual title *Devono-Carboniferous.* These were seen in three sections :—(1) 2,160 feet thick in Folding Mountain, the first foot-hill of the Rockies, where limestones, siliceous shales, and quartzites are brought up in a "sharply folded, slightly overturned anticline." (2) In Roche Miette, described as a notable landmark in view at a great distance, standing on the east side of the Athabasca River, a few miles below Jasper Lake. Here, in a section 3,300 feet in thickness, limestones and shales occur, the former holding the few and seemingly not very characteristic fossils which served to indicate the horizon of the beds, viz. Devonian. The following were the fossils obtained : *Atrypa reticularis*; *Diphyphyllum*, sp.; *Cyrtina*, sp.; *Spirifer* (or *Spiriferina*), sp.; cast of elongated spiral Gasteropod. (3) *Carboniferous* rocks were met with near Henry House on the Athabasca River, some 15 miles south of Jasper Lake. Here, again, the evidence upon which the age of the rocks is based is somewhat scanty, judging by the few fossils enumerated, as follows : *Reticularia setigera*?; *Productus* (very finely ribbed); *Spirifer*, sp.; *Dielasma* (cf. *D. formosa*, Hall). These were obtained in an exposure of

"black shales and flaggy cream-weathering limestone," three miles below Henry House.

Rocks of undoubted *Cambrian* age were met with on the north-east side of the valley between Tête Jaune Cache and Canoe River. "The squeezed conglomerate of the lower part of the series may be without much hesitation assigned to the horizon of the Bow River Series [*Lower Cambrian*], while the overlying schists and argillites probably belong to the same series, but may include, towards the top, beds of the upper division of the Cambrian or Castle Mountain group." No granite or other plutonic rocks were met with in the vicinity of the route traversed.

A great series of mica-schists were seen on the south-west side of the valley opposite Tête Jaune Cache, on Mica Mountain. The whole series, though differing somewhat from the Shuswap Series of the southern interior of British Columbia, shows the main characteristics of that series, and may be classed as such. The age of this series, as given by Dr. Dawson, is *Archæan*. The line of contact between these rocks and those of Cambrian age on the opposite side of the valley is hidden by superficial deposits.

The glaciation of the mountainous part of the region surveyed is briefly described, and evidence is found for the statement that the valley of the Athabasca contained a large glacier flowing northward down the stream. After the glacier had disappeared the valley was occupied by a large lake standing at a level of 550 to 600 feet above that of Jasper Lake, or 3,260 feet above sea-level. A long, distinct terrace, composed of silt and sand on the west side of Jasper Lake, marks this level.

The report concludes with a brief account of the distribution of the principal trees and of the game, large and small.

2.—On some Additional or Imperfectly Understood Fossils from the Cretaceous Rocks of the Queen Charlotte Islands, with a Revised List of the Species from these Rocks. By J. F. Whiteaves, LL.D., F.G.S., F.R.C.S. Mesozoic Fossils, Vol. I, Part IV, pp. 263–307, pls. xxxiii to xlix. (Geological Survey of Canada, Ottawa, November, 1900.)

As explained in the Prefatory Note by the Director, Dr. G. M. Dawson, the present memoir is an illustrated description of two collections of fossils from the Cretaceous rocks of the Queen Charlotte Islands, made by Dr. C. F. Newcombe, of Victoria, British Columbia, in 1895 and 1897. It contains also a revision of the nomenclature of some of the fossils previously collected from the same rocks by Mr. James Richardson in 1872 and Dr. G. M. Dawson in 1878. A brief summary of its contents will suffice, and this may be taken from Dr. Whiteaves' prefatory remarks. The revised list of species at the end of the memoir shows that 89 species of marine invertebrates are now known from the Lower Shales of the coal-bearing rocks of the Cretaceous system in the Queen Charlotte Islands. Of these one is a Coral (*Astrocænia*), three are Brachiopods,

representing the genera *Terebratula* and *Rhynchonella*, one is a Crustacean (*Homolopsis*), and the rest are Mollusca. The Cephalopoda are much more numerous, both in species and individuals, than the Gasteropoda, and the Ammonites are specially abundant. The latter seem to be remarkable for the presence of several species of *Desmoceras* (inclusive of *Puzozia*), and for the absence of *Baculites*, and of the numerous species of *Pachydiscus* which are so characteristic of the Vancouver Cretaceous. The number of species of Pelecypoda appears to be much larger even than that of the Cephalopoda.

The Canadian species have been in many instances compared with the original types contained in museums in the United States and in Europe. Thus every effort seems to have been made to ensure the utmost degree of accuracy in the identification of the fossils described in this work, which, it may be mentioned, appears fourteen years after the previous (third) part. The new species are well illustrated in the seven lithographic plates by Mr. L. M. Lambe.

3.—General Index to the Reports of Progress, 1863 to 1884. Compiled by D. B. Dowling, B.A.Sc. 8vo; pp. 475. (Geological Survey of Canada, Ottawa: S. E. Dawson, 1900.)

THOSE who have researches to undertake in any subject having a voluminous literature know well the value of that time-saving adjunct, a good index. The arrangement of the one before us is as follows:—Part I (pp. 5–20) contains the Reports, so classified that any country or district in a province can be found in its chronological order, the counties being set alphabetically under their respective provinces. The reports indexed date from 1863 (a summary from the commencement of the Survey) to 1884.

Part II (pp. 21–34) contains an alphabetical list of the "special examinations" of ores, minerals, or fossils that have been subjected to assay, analysis, microscopical examination, or scientific description.

Part III (pp. 35–475) forms the great bulk of the volume, and is termed "General Index to Reports, 1863–84." The arrangement in this part under reference to a place is usually chronological, commencing with the earliest, while under a subject the references are alphabetical, or in the case of substances of frequent occurrence, as gold, iron-ores, coal, etc., the localities may be grouped under provinces.

Special publications on palæontology and botany, which are issued by the Survey from time to time, are not included in this Index, but the "List of Publications" brought out at intervals supplies this deficiency.

We doubt not that the present Index will prove of great use to all who require to consult the publications of the Geological Survey of Canada, and they will not be chary of their commendation of the compiler whose zeal and industry made its completion possible. May his example be followed by many!

Arthur H. Foord.

REPORTS AND PROCEEDINGS.

Geological Society of London.

I.—January 23, 1901.—J. J. H. Teall, Esq., M.A., F.R.S., President, in the Chair.

After the formal business had been taken, the President, having requested all those present to rise from their seats, said:

"I feel sure that the Fellows will desire to express their deep sense of the grievous loss which this nation has sustained in the death of our late beloved and most gracious Sovereign, by assenting to the immediate adjournment of the meeting."

The meeting was accordingly adjourned.

II.—February 6, 1901.—J. J. H. Teall, Esq., M.A., F.R.S., President, in the Chair.

Dr. F. A. Bather, in exhibiting rock specimens, microscope sections, and photographs illustrating blavierite, ophitic diabase, felsitic porphyry, petro-siliceous breccia, and other igneous and metamorphic rocks of the Mayenne, said that the specimens had been collected by him in the course of an excursion of the Eighth International Geological Congress, under the guidance of M. D. P. Oehlert. In the basins of Laval and Coëvrons were many peculiar rocks due to the folding and crushing of stratified rocks penetrated by eruptive dykes. The tectonic features were illustrated by the maps of M. Oehlert and by the photographs. The slides were prepared in the Mineralogical Department of the Natural History Museum, where all the specimens would be preserved.

Mr. E. T. Newton exhibited some graptolites, which had been obtained by Mr. Herbert J. Jessop in the course of a prospecting expedition in Eastern Peru. The locality was in lat. 13° 40′ S. and long. 72° 20′ W.; Limbani, near Crucero, in the neighbourhood of the Rio Inambari. The graptolites are closely related to *Diplograptus foliaceus*, and indicate deposits of late Ordovician age.

Mr. A. K. Coomára-Swámy exhibited and commented on a lantern slide showing spherulitic structure in sulphanilic acid. This had been described and figured by Mr. Henry Bassett, Jun., in the Geological Magazine for January, 1901, pp. 14–16.

The following communications were read:—

1. "On the Structure and Affinities of the Rhætic Plant *Naiadita*." By Miss Igerna B. J. Sollas, B.Sc., Newnham College, Cambridge. (Communicated by Professor W. J. Sollas, M.A., D.Sc., LL.D., F.R.S., V.P.G.S.)

This plant, the remains of which are found in Gloucestershire, was considered to be a monocotyledon by Buckman, but a moss by Starkie Gardner. Material supplied by Mr. Seward and Mr. Wickes has given the authoress ground for the belief that *Naiadita* is an aquatic lycopod, and that it is the earliest recorded example of

a fossil member of the Lycopodiaceæ, resembling in proportions and outward morphology the existing representatives of the group. The specimens described show stems, leaves, and sporangia which appear to be borne laterally on the stem and to be embraced by the bases of the leaves. Stomata do not appear to occur, and the association of leaves of different types leads to the conclusion that the three described species are in reality but one. The stems consist mainly of long, thin-walled tubes covered with an epidermis of long rectangular cells; the leaves, in vertical section, show only a single layer of complete cells. The absence of stomata and cortical tissue may be explained, if the plant was submerged when living; but it is possible that the lower tissues of the leaf are lost, together with any stomata which may have been present.

2. "On the Origin of the Dunmail Raise (Lake District)." By Richard D. Oldham, Esq., F.G.S.

The author considers that the gap through the Cumberland hills is a natural feature whose remarkable character has not attracted the attention which it deserves. In form it is an old river-valley, now occupied by much smaller streams than that which formed it. A windgap of this character cannot have been formed by recession of watersheds or capture through erosion, for in such a case the stream on one side or the other of the watershed must necessarily fit its valley, while in the Dunmail Raise there is a misfit on both sides. The gap was in existence before the Glacial Period, and consequently cannot have been formed by ice. So, by a process of exclusion, the explanation is arrived at, which fits in with the surface forms, that the gap of the Dunmail Raise was formed by a river, which flowed across the hills from north to south, and cut down its channel *pari passu* with the elevation of the hills. The final victory of upheaval over erosion, whereby this river was divided into two separate drainage systems and the barrier of the Dunmail Raise upheaved, may have synchronized with a diversion of the head-waters and consequent diminution of volume and erosive power. It is pointed out that this explanation comes into conflict with previously published theories of the origin of the drainage system of the Lake District, inasmuch as the elevation postulated seems too slow to be explicable by the intrusion of a laccolite; and that the existence of a large river crossing the area of upheaval, and the maintenance of its character as an antecedent river-valley for a long period, show that the surface was originally a peneplain of subaerial denudation, and not a plain of marine sedimentation or erosion. From this it follows that the course of the main drainage valleys may not have been determined by the original uplift, but, with the exception of those which are old river-valleys, whose direction of flow has been reversed on the northern side of the uplift, may have been formed by the cutting back by erosion into the rising mass of high ground—in other words, that the principal valleys of the Lake District may be subsequent, not consequent in origin.

CORRESPONDENCE.

NAMES FOR BRITISH ICE-SHEETS OF THE GLACIAL PERIOD.

Sir,—It has often occurred to me that the discussion of our British Glacial phenomena would be facilitated by the adoption of regional names, such as have been found so useful in this respect in North America, for the different portions of the confluent ice-sheets by which our Islands were partly surrounded and covered at the period of maximum glaciation. I have especially felt the want of such names in describing the supposed condition of the basins of the North Sea and of the Irish Sea in Glacial times. The term 'Scandinavian Ice-sheet' often applied to the North Sea ice-field appears to me to be misleading, since it seems to imply that the basin was occupied solely by the outflow of glaciers from Scandinavia, whereas it is far more probable that it was maintained and augmented principally by the snowfall upon its own surface. The term 'Irish Sea Ice,' sometimes used to denote the ice-sheet filling that sea-basin, is likewise objectionable, as I found in a recent discussion where it was understood to imply the marine ice of a frozen sea.

After due consideration and discussion with colleagues interested in the subject, I am inclined to think that the term 'East British Ice-sheet' will be found suitable for the mass which occupied the bed of the North Sea off our eastern coasts, and spread thence, in places, inland. This will then find its complement in the term 'West British Ice-sheet' for the land-ice which filled the basin of the Irish Sea, and encroached upon our north-western lowlands.

We already speak of the 'Pennine Ice' for the great confluent glaciers which covered the greater part of the Pennine region, and of the 'Lake District Ice' for the masses of that region, and these terms need no revision.

Then, for the ice which overspread the greater part of Scotland to the exclusion of the 'East British' and 'West British' sheets, we might apply the general term 'Caledonian,' with such local subdivision as may be hereafter found convenient. And, similarly, the 'Hibernian' (or 'Ivernian') would be that which covered Central Ireland, and the 'Cambrian' that which shielded the greater part of Wales.

More restricted local terms might still be introduced to distinguish well-defined portions of these sheets, and the lobes into which they probably split towards their termination.

I shall be glad to learn whether the terms above suggested are likely to be approved of by glacialists who hold the 'land-ice theory' in regard to our drifts. G. W. Lamplugh.

Tonbridge.
January 20, 1901.

CHEVIOT PORPHYRITES IN THE BOULDER-CLAY OF EAST YORKSHIRE.

SIR,—I can confirm Mr. Stather's opinion[1] (expressed in the GEOLOGICAL MAGAZINE for January, 1901) that the porphyrites of the East Yorkshire Boulder-clay were probably derived from the Cheviots. When I was stationed at Bridlington Quay on the Geological Survey, Mr. C. T. Clough, who mapped the Cheviots, came to the Quay in order to identify, if possible, the far-travelled erratics in the Boulder-clay. We examined the shore and cliffs from Bridlington Quay to Filey, and found a large number of porphyritic rocks, which Mr. Clough said might very well have come from the Cheviots. J. R. DAKYNS.

SNOWDON VIEW, NANT GWYNNAN, BEDDGELERT, CARNARVON.
February 11, 1901.

MUSEUM EXHIBITION CASES.

SIR,—The new Geological Museum now being erected here will have high windows and a long south aspect. The effect of this will be that the sun will fall suddenly on glazed cases and as suddenly pass off them, thus by the expansion and contraction of the air causing dust-carrying currents to force themselves through every chink. From this cause it costs about three times as much to keep cases and specimens clean on the side exposed to the sun as it does in the shaded part of a museum. This may be obviated by elastic diaphragms (which would hardly allow sufficient movement for such large cases as ours) or by small sliding shutters packed with cotton-wool something like Tyndall's respirators.

Can any of your readers refer us to museums in which such a system has been tried or give us any advice on the subject before our cases have been built? T. MCKENNY HUGHES.

WOODWARDIAN MUSEUM, CAMBRIDGE.
February 19, 1901.

OBITUARY.

JAMES BENNIE.

BORN SEPTEMBER 23, 1821. DIED JANUARY 28, 1901.

WE regret to record the death of Mr. James Bennie, at the age of 79 years. For many years he was one of the fossil collectors of H.M. Geological Survey, and was well known to local geologists in the west of Scotland. In early life, before he joined the Survey, he was employed in a paper manufactory in Glasgow, where he devoted his leisure hours to the examination of the glacial, interglacial, and post-glacial deposits of the west of Scotland. He likewise collected fossils from the various Carboniferous horizons in that region. The results of his labours were published in the Transactions of the Glasgow Geological Society, and his glacial researches were communicated to Dr. Croll in 1867, as acknowledged in the "Life and Work" of that investigator. His Survey career, which commenced in 1869, was marked by his great

[1] See "The Sources and Distribution of the Far-Travelled Boulders of East Yorkshire," by J. W. Stather.

knowledge of the fossiliferous bands in the Carboniferous rocks of Central Scotland. He paid special attention to the occurrence of micro-organisms in the weathered shales of that series, which resulted in the discovery of many forms new to science, described and figured by various specialists. He was the first to record the occurrence of Holothurians in the Carboniferous rocks of Scotland, and was likewise the first to obtain the remains of Arctic plants in the silt and peat of vanished lakes that formerly occupied hollows in the Boulder-clay. With the remains of Arctic plants he discovered fragments of a phyllopod Crustacean, which is now found living only in fresh-water lakes in Greenland and Spitzbergen. Two years ago he received the Murchison Fund from the Geological Society of London, in recognition of his work. Quiet and unobtrusive in manner, and fond of literature, he showed throughout his life a keen love of nature.—*Scotsman*, January 30.

MISCELLANEOUS.

The New Director of the Geological Survey of the United Kingdom and of the Museum of Practical Geology, Jermyn Street, London.—We have just been informed that J. J. H. Teall, Esq., M.A., Vice-President of the Royal Society, President of the Geological Society of London, has been appointed to succeed Sir Archibald Geikie, F.R.S., as head of the Geological Survey. Mr. Teall is an eminent Petrologist and the author of many important papers on geology; he has published a most valuable monograph on British Petrography, with which special branch of the science his name will always be connected. He is universally esteemed amongst geologists, and especially by the members of the staff of the Geological Survey, for his geniality and urbanity to all his fellow-workers. As President of the Geological Society he has also won golden opinions.

The New Professor of Geology at University College, Gower Street.—The Rev. Professor Thomas George Bonney, D.Sc., LL.D., F.R.S., F.G.S., who succeeded Professor John Morris, F.G.S., in the chair of Geology at University College, in June, 1877, and has occupied that post with such eminent success for 24 years, retires this month and is succeeded by Mr. Edmund Johnstone Garwood, M.A., F.G.S., of Trinity College, Cambridge, a gentleman already distinguished by his geological observations and writings in the Quarterly Journal of the Geological Society, the Geological Magazine, the Royal Geographical Society's and other scientific journals. Mr. Garwood has done excellent field work in the Alps, the Himalayas, in Spitzbergen; and in writing upon the Magnesian Limestone and the 'Great Whin Sill,' and the Life-zones of the British Carboniferous Rocks. He has been for some years a Lecturer at Harrow, and as a University Extension Lecturer is well known and esteemed by the scientific public.

Although Professor Bonney is relinquishing the Chair of Geology at University College, he intends still to pursue his scientific and literary work and will continue his clerical duties as heretofore.